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OZOKERITE.

THIS peculiar mineral has for some years past occupied a very important position in its useful application to the improvement and preservation of insulated conductors. Being an insulator itself of a high quality, it readily lends itself, from its wax-like nature, to a combination with other insulators, or with textile fabrics.

Hitherto it has not been found in any considerable quantities, except in Galicia and Moldavia, in Austria, from which places our supplies have been received; but latterly an important discovery has been made of some mines in Utah, in the United States, which are now being opened out with very great success. The supplies, which hitherto were only obtainable from Austria, will now, fortunately for America, be obtained there. This is a favourable circumstance, as very large quantities of ozokerite are used in the States for purposes other than those electrical. It is employed for the numerous needs for which "wax" is required, and in the electrical industry it is used either by itself, or in combination with other materials. Certain well-known insulating products rest upon ozokerite as their principal support.

This mineral, which is fairly well known, is obtained by mining, but from the careless character of these operations its production has been attended with some risk to life. Small quantities have been found in the United Kingdom, but our supplies commercially have come from Austria, and the shipments to this country have been very large, as ozokerite has been extensively used in what may be termed the "wax," as well as the electrical, industry.

Ozokerite, or "ozokerit," as it is indifferently spelt, is composed of about—

Hydrogen	13·75
Carbon	86·25

And it melts at a rather low temperature, but slightly higher than "paraffin" wax, to which, in many ways it bears a faint relation. The character of the mineral slightly varies, and its quality or degree of hardness undergoes variations according to the different methods of purifying and refining. These qualities differ to the extent that the melting point extends from as low as 140° to about 170°, which is about the finest quality that is produced.

The fact that ozokerite was an insulating substance was known soon after its introduction commercially into this country, for we find, by referring to our patent records (where the history of many a subject may be traced), that a patent was taken out on the 31st December, 1869, by Augustus Matthiessen, for an "insulating substance for the covering of electric telegraph conducting wires, and for electric telegraph apparatus and insulators." This invention, we learn, consists in the application of "ozokerite" or "earth wax." "Ozokerite may be applied in its natural state, or its residues or products may be incorporated with gutta-percha, India-rubber, or other known insulating substances, with or without the admixture of fibrous substances."

In 1872, on the 29th April, the late Henry Highton applied for a patent—for which provisional protection only was granted—for the application to the conducting wires of cables which are covered with gutta-percha, caoutchouc, or similar materials, of a solution of paraffin, *ozokerite*, or shellac, to fill up the minute pores and improve the insulation.

In 1875, on the 27th May, a patent was applied for and granted to Messrs. Field and Talling, which is interesting, as it relates to the first patent in 1869. "The compounds made according to specification 3778-1869, viz., by mixing together ozokerite and gutta-percha, or like substances, by heat, having been found to be brittle and therefore useless as coatings for telegraph wires, the present invention consists in using solvents to dissolve the 'ozokerit' and elastic gums, or in masticating with or without the use of solvents."

In the same year, on November 25th, a patent was taken out by the late W. T. Henley for improvements in insulating conductors. "The improvement in the method of insulating the conductor consists in curing the India-rubber covered conductors in ozokerite, paraffin, or other similar hydro-carbon, instead of in high-pressure steam." "A double vessel, or steam-jacketted cylinder, is used, the outer vessel or jacket only being charged with steam; the inner vessel is charged with hot hydro-carbon." "According to another plan, the core is cured by high-pressure steam, dried, and treated with ozokerit or paraffin under heat and pressure." In the following year Mr. Henley took out a further patent for passing the insulated conductors through ozokerite. Subsequently patents were taken out by others, but these have no particular interest.

Previous to this date, and through many subsequent years, the Messrs. Field, who were the sole importers of "ozokerite," were investigating with much skill and trouble, and at considerable expense, the various qualities and peculiarities of this material; and they succeeded in producing the various very fine qualities of ozokerite for electrical and other purposes which are generally so well known. It may be mentioned, however, that they were successful in obtaining a compound of this material and India-rubber, which they termed "nigrite," which has been used for insulating wire in a manner similar to gutta-percha. We are not aware that this wire has come into any extensive use, but that it has been tried and found capable of being manufactured is a matter of fact. We have ourselves tried some experiment with this kind of wire, extending over a very considerable period, and have found it to stand many severe tests, remaining after the lapse of several years in an unaltered condition.

Amongst the users of ozokerite will be found the Postal Telegraph Department, who have for a period exceeding eleven years used it almost entirely for the protection of their underground gutta-percha insulated wires, as a substitute for the Stockholm tar hitherto almost universally used, but abandoned on account of its action upon the quality of the gutta-percha wire at that time employed. The action of Stockholm tar upon gutta-percha was well known as tending to considerably reduce the insulation, but it had been, and still is, in certain quarters used in combination with some fabric, as the best preservative for gutta-percha wires underground or in tunnels. The gutta-percha covered wires were protected with tape well-tarred, and with the best quality of material this had been found to answer remarkably well; but about the year 1878 the use of tar was abandoned, and some experiments having been for a length of time tried with ozokerite, it was found suitable, and since that date it has been almost continuously used. The use of ozokerite was tried experimentally several years before tar was finally abandoned. As a preservative by itself it was not found to be of the practical value anticipated, as it did not tend to preserve the fabric it was used in connection with to the extent expected. A certain admixture of Stockholm tar—whose antiseptic qualities have been so well proved—was found to give the desired results, and since the abandonment of pure tar the underground gutta-percha wires of the Post Office have been protected by tape well soaked in a mixture of ozokerite and tar. As a practical result it may be worth while mentioning that the use of ozokerite has been found to improve the insulation.

The preparation of the cables for the underground street of London and provincial towns is an important work, and has invariably been carried out, formerly by the Electric and International Telegraph Company, and subsequently by the Post Office at Gloucester Road Factory. Where the insulated wires have been received direct from the manufacturers, and first having been thoroughly covered with the tape prepared with ozokerite compound, have been made into the necessary cables. The tape used for the purpose is of a special class, and is first passed through a bath of compound and then cooled by passing through water. The compound consists of about three parts by weight of ozokerite to one part of Stockholm tar; it is kept heated in a boiler, and maintained at the lowest temperature at which it can be kept fluid; the water cools the prepared tape, and prevents it sticking on being wound off on to a bobbin. The wires are taped in the ordinary manner; gutta-percha wire thus treated is found to last in a very satisfactory manner. The quality of the ozokerite used by the Post Office is different to the harder sort mostly in use, being softer and possessing somewhat different characteristics, it melts also at a lower temperature, somewhere about 156° Fahr., and, as may be supposed, mixes thoroughly with the tar.

It will be seen, therefore, from what we have said that this mineral or "earth-wax" is an important industry, and that a very large supply is in demand not only for our underground wires, but also for our electric light wires, for in their insulation and in their external preservation all cable and wire manufacturers use "ozokerite" very largely. It would be very difficult to supply its place for the manufacture of electric light wires, for whilst ozokerite has many of the qualities of paraffin wax, it has others which that material does not possess. The continuous supply of this material is therefore much to be desired, and the recent discoveries in the United States are consequently welcome.

TELEGRAPHY.

THE disappointment which from time to time has been expressed in the last few years with reference to the conduct of the Society of Telegraph Engineers (now the Institution of Electrical Engineers) in apparently looking coldly on the branch of science for the promotion of which it was originally founded, is, we believe, confined to but a small knot of malcontents. The comparative indifference with which the subject of telegraphy and its directly allied branches is regarded is, of course, due to the all-absorbing interest, both commercial and scientific, with which the electric light industry is regarded. That there remains but little further to be done in telegraphy, whether overland or submarine, cannot perhaps be admitted; but, at the same time, it is, we think, a fact that the very general statement that the science is "still in its infancy," certainly does not apply at the present day. If we compare the events of 25 years back with those of the to day, we notice a great change; the laying of a submarine cable 25 years ago was always heralded long before the work was commenced, and the completion was made the opportunity for *fêtes* and rejoicings, &c., which are never dreamt of in our time. In fact, the submersion of even a very long cable is now such a matter of course that practically no public attention is paid to the matter. Of land telegraphy we hear equally little. It is true that, from time to time, ingenious mechanical ideas which professedly would greatly improve the working of the wires are patented, but it is rarely, if ever, the case that they are adopted, or found beneficial in practice. The inventors, of course, are bitter in their cry that *their* ideas are most unjustifiably blackballed when they themselves, who have had no practical experience, know so much better than those who have, what is really of value. No doubt, in some cases, partial injustice is done, but we believe it is very rarely so. The idea which has been suggested of a new Society, to specially deal with telegraphy, telephony, &c., being started is, we think, quite absurd; the numbers which would join it would, we are sure, be insignificant, and papers would be read to a depressingly thin audience. But after all, as regards the Institution of Electrical Engineers, the matter rests in the hands of the members themselves; to complain that telegraph matters are neglected, means that no papers are read on the subject, and, again, this means not that papers are submitted and rejected, but that no papers at all are offered, which again looks very much as if there was really very little to be said or discussed.

IN the *Standard* of Tuesday, the 3rd inst., will be found a four-column display by the "Eminent" Mr. Harness, which is devoted to abuse of the Medical Profession and to the glorification of his own appliances. As one of the columns is headed "A Disclaimer," we fancied he might have been sufficiently upright to print the disclaimer made by Dr. W. E. Steavenson (in charge of the Electrical Department of St. Bartholomew's Hospital) against a paragraph appearing in the said Harness's advertisements, in which the Doctor is supposed to recommend the use of the advertiser's Electropathic Belts. The paragraph in question is a reprint from the *Family Doctor*, headed "Debilitated Constitutions," stating that the Consulting Physician and Electrician of St. Bartholomew's Hospital has, we are glad to say, made a move in the right direction. After finding that physic is practically useless for the relief of nervous sufferers, he writes:—

> There is no doubt that electricity is one of the most powerful nerve tonics we possess. No agent so quickly restores the depressed condition of the system resulting from illness. In all states of nervous depression, as from long mental strain or overtaxed bodily powers, general galvanism has proved a refreshing and most invigorating tonic.
>
> The next point, therefore, to be considered, is as to the best method of applying these galvanic currents to the system pleasantly without any discomfort, and for this purpose we cannot do better than strongly recommend all nervous sufferers to wear one of Harness's electropathic belts.

ANY reader of this would conclude that Dr. Steavenson advocated the use of these belts, but such is not the case, as the following disclaimer plainly shows. "The last paragraph is from the *Family Doctor*. I have never recommended the use of Harness's belts. The quotation from my writing is taken from a paper I read before the British Medical Association at Belfast in 1884. In a subsequent part of the same paper I have said":—

> The galvanic belts and portable batteries, so extensively advertised, are not of the slightest use, and are great impositions on the public. If it were possible to pass a weak current of electricity through the body, or any part of the body, for an indefinite time, no doubt great tissue changes would take place. It would be impossible for such a powerful agent—one capable of splitting up all chemical compounds—to be passed through the body without causing great tissue-changes. But the skin offers such a resistance to the passage of electricity, that the body may almost be said to be insulated. No weak current, such as is produced by these battery belts, could pass through the skin. If one pole from the battery belt be applied to the body, and a galvanometer introduced between the body and the other pole, no deflection of the needle can be detected. If the current from these appliances were strong enough to overcome the resistance of the skin, sloughs would in a short time be produced at the points of application of the electrodes, a sore first appearing at the point of application of the negative pole. The same objection holds good with regard to the electric brushes; no battery that they can obtain could produce a current strong enough to penetrate the skin of the scalp.

"As direct reference is made to me in the public press in a way calculated to give a wrong impression of my views, and in my opinion to the detriment of the public, I have felt it my duty to ask you to insert this disclaimer."

THE advertisement column, however, does not mention a word about Dr. Steavenson's repudiation, but is confined to a disclaimer on Mr. Harness's part, of having been now, or at any time, a medical practitioner, and stating that he stands on his own ground as an electrician. On the top of the next column appears in full the extract from the *Family Doctor*, and without a word to show which are the opinions of Dr. Steavenson and which are those that emanate from the editorial brain. If the "Eminent" is so fortunate as not to come within the clutches of the law, the same fortune does not attend his subordinates. Mr. Joseph Fredk. Leeson (registered as L.R.C.S., Edin., 1858; L.R.C.P., Lond., 1861), who held a post under "The Medical Battery Company, Limited" as consulting physician, was summoned before the General Medical Council: "For that he, being a registered medical practitioner, acts as cover of, or by his presence, advice and assistance, enables one Cornelius Bennett Harness, an unqualified person, to carry on the business or profession of a medical electrician, and to practise as if he were duly qualified under the style of 'The Medical Battery Company, Limited,' and 'The Electropathic and Zander Institute,' at 52, Oxford Street, London, W., the said Cornelius Bennett Harness publicly advertising himself as 'The Medical Battery Company's Consulting Medical Electrician.'"

THE evidence on which the charge against Mr. Leeson was based was a declaration by Mr. Wilson, a wine merchant of Oxford, who, seeing an advertisement in the *Standard* newspaper, and thinking that he was suffering from sciatica, went to the Institute with the intention of buying a guinea belt. He was told there that would be no good, but for the sum of £25 he could be cured, but that it was necessary to come to London once a week to have the battery applied. Mr. Wilson then agreed to pay 10 guineas down and another 10 guineas when he was cured. The assistant then introduced him to their physician, who proved to be Mr. Leeson. A battery was applied to him for 15 minutes, and then a belt was put on him, for which he afterwards sent a cheque for five guineas. That was on August 6th, 1887. In November following he received an account for two guineas for the physician's fee, and as he refused to pay he was County Courted. The case was heard on December 16th, Mr. Leeson being called as a witness, describing himself as the medical officer of the Medical Battery Company. The case was determined in Mr. Wilson's favour, the plaintiffs having to pay the costs.

IN defence it was stated that Mr. Leeson was in no way answerable for the claim made against Mr. Wilson, also that the College of Physicians had considered the case, and had resolved that a licentiate might be a member of a trading company. In cross-examination Mr. Leeson said that Mr. Harness was an "M.D." of Philadelphia, and the diploma was hanging up in the establishment (here Dr. Glover said that the so-called University of Philadelphia had been deprived of its charter for issuing bogus degrees), that Mr. Harness did not "practice," he gave electrical treatment; that several patients had been cured of hernia, but they did not pretend to cure all; Mr. Leeson further said that when a patient sent a diagnosis of his case it was forwarded to Dr. Vigoroux, who then communicated with Mr. Harness; and that Dr. Vigoroux was not qualified in this country. Mr. Harness gave evidence in support of Mr. Leeson, that the action against Mr. Wilson was a mistake of the clerks; he knew nothing of it personally for weeks afterwards. He had written a letter to a medical journal threatening an action unless an apology were sent to him for something that appeared therein. There was no apology to hand, nor did he execute his threat. The statement made was a gross lie. Mr. Wilson's account of the 25 guineas was an absolute falsehood. Mr. Leeson was a salaried officer of the company to whom patients were referred to see if they were fit persons to undergo an electrical treatment. After deliberation the Council, by the mouth of the President (addressing Mr. Leeson) said: I have to inform you publicly that the Council after long deliberation has come to the conclusion (1) that you have committed the offence charged against you; (2) that the offence is, in the opinion of the Council, "infamous conduct in a professional respect;" and (3) that the Registrar has been directed to erase your name from the Medical Register. We note, with surprise, that several doctors are inclined to place faith in the electropathic belt treatment of the President of the British Association of Medical Electricians, although there is little doubt that they have mistaken the virtues of flannel for the wonders of electricity. We were under the impression that medical students found it necessary to include an elementary knowledge of electricity as applied to curative purposes in their course of studies, but probably the "medicine men" who, by their ill-advised support, give strength to Harness's pretensions, are "old timers," and never had the advantages of the younger generation. Harness has often threatened to bring libel actions against quite a varied assortment of individuals and class papers, but it is questionable whether he does not lay himself open to retaliation of a serious kind by his brazen-faced style of advertising. What will thoughtful people feel when reading such bathos as is contained in the following extracts:—

> Mr. Harness is not connected with any of the medical colleges neither does he ever intend to belong to any of their tyrannical and vindictive "class" institutions or societies. The British medical faculty persecute their more liberal-minded members to such a cruel extent that Mr. Harness feels it is his duty to bring public criticism to bear upon their councils. . . . The medical profession, like any other professional combination, is composed of all sorts and conditions of men. Many there are who, happily for poor humanity, devote their lives to the study of the human system. . . . But with the mass of the profession it is far otherwise. After the formality of "walking" (or rather running through) "the hospitals," a short "cram," kept up with considerable vigour for a brief period just prior to the examination, carries them through their not very severe tests, and then they are turned out upon the world. . . . Large numbers of them are notoriously defective in diagnosis, unskilled even in the preparation of "the mixture as before," and capable only of looking very wise and concealing their ignorance by their silence.

Generally, the medical profession is summed up as a combination of ignorance and orthodoxy, and the medical press, it is asserted, lends itself to this. Surely such slanderous reflections upon the highest and most noble of all professions will not be allowed to pass unnoticed?

THE Highway Committee of the London County Council has recommended the appointment of a competent person to fulfil the duties of an electric inspector at a salary not exceeding £200 a year. We are afraid if it is the intention of the County Council to obtain a practical electrician at so low a salary they will be greatly mistaken. They may receive many applications for the post and emoluments, but out of those who apply there will be few who possess the requisite knowledge. It is absurd to think of paying a man of education at an equal rate with the foreman of the dustmen. However, after a trial of their £200 a year man they may come to the conclusion that it will be necessary to increase the salary very considerably.

MR. JOHN MARSHALL, the eminent surgeon, in a masterly lecture on "Cancer" referred to the electrical treatment of Dr. J. Inglis Parsons, whose method of arresting their growth is well known to readers of the REVIEW. Mr. Marshall seemed to think that the application of electricity must necessarily be repeated many times, but Dr. Parsons states that his experience goes to show that usually a repetition of the application is unnecessary, and that one operation will cause atrophy of the growth. The majority of his cases have been those in which the knife had failed or in which the disease had progressed too far for the knife. With most of these he had to operate more than once, because there had been so much growth that it could not all be treated at one operation. His first patient was under treatment for a little over three weeks in August of last year, but since then it has not been necessary to repeat the applications. In our next issue we hope to give our readers some further experiences of Dr. Parsons.

REPORT ON THE APPLICATIONS OF ELECTRICITY TO RAILWAYS.

By MM. E. SARTIAUX and Z. WEISSENBRUCH.

(*Continued from page* 612.)

Section 3.—*Accumulators and a dynamo turned by the axle of a carriage.*

In the experiments on the Belgian lines and the East of France, performed in 1883, a single battery of accumulators was placed alongside the dynamo. It served only to feed the lamps at stoppages, or when driving very slowly. A mechanical arrangement allowed of the dynamo being always made to turn in the same direction. An electric safety interrupter disconnected the dynamo and the accumulators automatically when the speed of the train descended below a certain minimum (30 kilometres per hour). The regulation of the current by the introduction of resistances, and the commutations necessary to cause the current of the dynamo to act upon the circuit of the lamps upon that of the accumulators, or even upon both at once, was effected by hand in the experiments made on the Belgian lines. The safety interrupter was, we believe, improved in the experiments on the Eastern of France so as to effect all the communications.

Since that time there has been discovered the regulative action of the secondary batteries, introduced either in parallel or in series into a circuit of variable electromotive force. It has therefore been found advantageous never to remove the battery of accumulators from the circuit of the lamps.

This battery serves as an overflow when the charging current of the dynamo is being admitted, and, on the other hand, when the primary electromotive force falls below its own, it yields a compensatory secondary current.

The London, Brighton and South Coast Railway has applied this principle since the time when it abandoned accumulators alone, and sought to derive the motive power from the axle of a vehicle. It employed to this end an interrupter regulator (Stroudley and Houghton's system) acting on the brushes of the dynamo, and keeping up the direction of the current independently of that of the movement of the train.

In the first trials it also made use of two batteries, one of which was being charged whilst the other furnished the light. The commutation was effected by hand.

The *Sudbahn* (Austrian) has experimented on Calo's system, in which the principle of regulation by accumulators was applied in a still more complete manner, since a centrifugal automatic commutator, which served as a safety interrupter, introduced into the circuit a variable number of secondary elements. These were connected in two parallel series, in order that their regulative action might be more perfect, the resistance less, and the electromotive force more unvarying.

The trains worked between Vienna and Trieste, and during the ascent of the Sœmmering, the accumulators which had to feed the lamps had not a capacity sufficient for the purpose.

According to a communication to the Congress from the Sudbahn the experiments have been broken off principally on this account.

In the experiments of the Direction of Frankfurt-on-the-Main, the accumulators were placed in the circuit in series, so as to diminish the number of elements necessary. The battery was inserted in the circuit in two parallel series during the action of the dynamo. When it merely fed the lamps it was in a single series. The current given by the dynamo was constant.

This system, for which the Maschinen Fabrik, of Esslingen, and the Elektrotechnische Fabrik, of Cannstatt, have obtained patents, was extremely complicated, and required minute attention.

The Cannstatt Works have since improved the system. Each carriage is made to carry its own supply, so as to render it, in case of need, independent of the others. The accumulators being placed in parallel, it might have been feared, *a priori*, that the differences of their electromotive forces might have hurtful effects. Experience has shown that both in charging and discharging there are produced compensations which equalise any differences which may exist at the outset among the batteries. This property of accumulators, however, has long been known, and has been utilised by Messrs. Beaman, Taylor, and King for establishing the central electric lighting station at Colchester.

The Timmis system, tried on the Midland Railway, resembles the earlier Wurtemburg system. It differs in point of principle merely by the addition in each carriage of an electric check commutator, worked from the guard's van by means of a third wire, so that the lamps cannot act without the consent of the chief guard. By means of a fourth wire, the accumulators may be made to actuate signals at the disposal of travellers in every compartment.

M. Tommasi employs a separate exciter, but in most other experiments the exciting circuit was a simple derivation. M. de Calo formed the inductor of two distinct layers; the one of fine wire gave the magnetic field, whilst the other, of thick wire, was connected to the circuit of the lamps and the accumulators.

In the Stroudley and Houghton system, tried on the South-Eastern, the dynamo was excited by two wrappings; the one was an ordinary shunt taken from the extremities of the armature, the other, coiled in the opposite direction, was formed by the circuit of the accumulators. We comprehend immediately that the object of this arrangement is to compensate the variations of the electromotive force.

We do not know exactly the ultimate arrangement adopted by the London and Brighton Railway for the Brush machine which is there in use. The manager of the Anglo-American Brush Company informs us that the dynamo, driven by the axle, must be able to commence by furnishing the current at a speed of 16 kilometres per hour, and of maintaining it at an almost constant tension until the speed of the train increased to 96 kilometres. The Gramme and Siemens dynamos were tried without success. The Brush dynamo was then modified, and the encouraging results caused it to receive a form such that without any special regulating apparatus it maintains the electromotive force constant when connected with a battery of accumulators.

It is known that the lighting of the express from London to Brighton leaves nothing to be desired. Nevertheless, the electromotive force and the intensity vary within wide limits—from 50 to 80 volts, and from 35 to 80 ampères, according to the speed of the train.

To sum up, we see from the foregoing that the plan of feeding the lamps directly by dynamos has been abandoned. Accumulators have become an essential part of the system; they serve at once as magazines when the dynamo is rendered inactive, and as regulators when it is in movement. Often the dynamo placed on the carriage serves merely to charge the reserve of accumulators. In this case its object is to produce:—

1. A decrease in the number of secondary elements, which would be necessary if they had to be charged at some fixed station.
2. The supersesion of transhipping the accumulators, and of stopping the train to re-charge them.
3. The utilisation of the *vis viva* lost by the train.

4.—*Accumulators with a Dynamo Driven by a Steam Engine Supplied by the Locomotive.*

This system is merely a variety of the foregoing, since the use of a dynamo without accumulators, driven by the steam of the locomotive, has been abandoned on account of the irregularity of the light.

The engineers of the line object to this system, because the locomotives are often at the limit of their power, and that it would be dangerous to impose a new duty upon the engine driver. Electricians reply that the locomotives have from 600 to 800 horse-power, and could consequently afford 2, 3, or even 7 horse-power, except when on very steep gradients, and that the installation might be placed in the guard's van, requiring no further attention than to cut off the supply of steam on coming to a steep incline.

In Europe we can merely mention the old experiments made on the Great Eastern and Great Western lines, and more recently on the Imperial Russian train. On the Great Eastern the light was excellent, and there occurred no irregularity, but the system was abandoned as too costly. In the United States this system is more in favour, as the construction of the American plant does not lend itself readily to obtaining power from the axle.

5.—*Electric Lighting in Tunnels, the Current being Transmitted by Means of a Central Rail.*

The Glasgow City and District line is much intersected with tunnels, so that on a single journey the trains are in the dark for an hour.

It was therefore proposed to light them up in the tunnels by means of a single electric station. For this purpose there was laid down in the middle of the track a third insulated rail conveying the current, the return being effected by the ordinary rails. The carriages carry two contact pulleys mounted on a spring; a steel brush carried by each train serves to clean the rail.

The central rail is divided into three parts, the extremities of which are respectively at 2,014, 1,308 and 846 metres from the dynamo. The section of each of the three parts of this conductor increases progressively as it leaves the dynamo, so that the fall of the potential is at most only 10 volts.

The dynamo is of the Compton system, compound and self-regulating, and has a difference of potential of 110 volts at its extremities. It is driven by the same engine which serves to light up one of the stations of the tunnel.

Chapter II.—*The Electric Lighting of the Train as regards Cost.*

Unfortunately it is impossible at present to elucidate this question, on account of the insufficient experience as yet at our disposal. Most railways which have tried the light have done so for so short a time, that the results are not decisive. On the other hand, the cost of lighting with oil or gas is not everywhere alike, so that it is impossible to form comparisons of even moderate accuracy. The calculations given vary very widely. Thus, on the Connecticut River line, the daily expense is said to be 11 centimes daily per lamp (accumulators or dynamo), or 1·83 centime per lamp hour. The *Railway Review* brings out a figure of 5·17 centimes per lamp-hour, whilst the *Railroad Gazette* calculates the cost at 3·28 centimes.

Chapter III.—*Comparison of the Cost of the Electric Light as Compared with Gas Burners or Oil Lamps.*

The figures reached show that:—

1. The price of lighting with accumulators alone charged at fixed stations without making any demands upon the engine, is in the United States from 5 to 5·6 centimes with 12 to 16 candle lamps, and that in Europe it may be effected at 1·9 to 3 centimes for 6 to 8 candle lamps, fitted with reflectors.

2. That according to experiments made in Europe, it is possible to charge accumulators in the carriages by means of power taken at the axle without exceeding the figure of 4—5 centimes per lamp hour (of 5 candles), still retaining the power of breaking up the train, and that this figure is still capable of reduction.

3. In the United States, in long trains the cost price per lamp hour (16 candles) has been brought down from 5 to 3·5 centimes, the steam necessary for working the dynamo being taken from the locomotive.

Summary.

It is impossible to study the question of the electric lighting of trains without being struck with the great progress made in a few years, and without recognising that electricity is close upon the solution of the problem, as regards the economy, the beauty, and the intensity of the light. The small quantity of heat generated by incandescence lamps, the fixity of the luminous point, the ease with which it can be placed at any part of a compartment, render it the mode of lighting to be preferred, if we wish to read for a long time without fatigue.

The system which seems the most advantageous is that of accumulators placed under or upon each carriage, with a battery for the whole carriage or for each lamp, the accumulators being charged at fixed stations. The weight of the accumulators, and of all the appliances necessary for the twenty-two electric lamps of a saloon carriage is 550 kilos.

If special reasons render it desirable to dispense with the trans-shipping of the accumulators, or that the train cannot stop for the time necessary for charging, experiments made in America and England show that it is not impossible to render it entirely independent, whilst retaining the power of separating the carriages. It is merely needful to place a dynamo in the brake van, and to work it either from the axle or by steam from the locomotive.

(*To be continued.*)

ELECTRIC WORKS AT ALZANO-MAGGIORE.

[FROM A CORRESPONDENT.]

I AM to-day enabled to give you some information on an interesting electrical installation which is being put up at Alzano-Maggiore, a small town near Bergamo, in the Valle Seriana, one of the most industrial valleys of Lombardy.

The abundance of waterfalls which distinguishes this district makes it especially suitable for electric installations for the distribution of light and power. In the spring of this year a company has been formed at Alzano, entitled "Societa Alzanese di Elettricita," which undertakes to utilise the motive power of a waterfall situate about two kilometres from Alzano for the production of electrical energy for yielding light and power. For this purpose a competition was invited, the prospectus of which was drawn up by Prof. Zunini, of the Milan Electro-Technical Institute. In accordance with this prospectus two installations were to be erected, acting independently of each other, each consisting of a turbine with a horizontal axle, which, with a fall of 128 metres, yields 65 effective H.P., and is at once connected with a dynamo of the capacity of 48,000 watts. For one installation which is to serve for the production of light the use of alternating current machines with transformers, with a primary tension of 2,000 volts, was prescribed, whilst it was left free to the competitors to use in the other installation for the transfer of motive power either alternating current generators and motors or continuous current dynamos. At the same time the prospectus placed in the first line the use of alternating current motors in order to effect uniformity in the entire installation, and to render it possible in case of need to use the alternating current generators of the motive power installation in place of the illuminating dynamo.

Of the three firms which took part in this competition, two, in accordance with the prospectus, proposed the erection of two mutually independent sets of machinery and conductive nets, namely, one installation for the supply of light, and a second for the distribution of motive power, the latter on the continuous current system. The Societa Generale Italiana di Elettricita Sistema Edison, which also put in an application for the work, came forward with a single unitary project, founded on erection of a single installation for the production of a current and a single conductive net, employing alternating currents with transformers and alternating current motors. This project of the Italian Edison Company was recognised by the Commissioners as the most advantageous and best adapted to the circumstances, and it was accepted for execution.

At present the above company is fitting up at Alzano-Maggiore two Zipernowsky alternating current machines of the type A_5, each of which, with a rotation of 500 turns per minute, is able to produce a current of 25 ampères and 2,000 volts, = 50,000 watts. These machines are directly connected with the turbines by which they are driven, whilst the two exciting dynamos (of the Ganz type, Δ_1, each for 30 ampères × 110 volts) are turned on common shafts by means of belts, and for this purpose they are fitted up with belting arrangements.

Besides the various customary controlling and measuring apparatus there is an automatic current regulator (automatic rheostat) which serves for the converter support of the secondary tension in the distributive net in order to compensate variations in the speed of the motors or in the consumption of current.

A supply rheostat (lamp battery), consisting of 24 groups of 21 lamps each, and a 24-fold key-cut-out serves to receive the current of either machine on inserting or withdrawing the dynamos.

The installation of a third set of machinery of equal size is already in prospect in which two alternating machines arranged parallel will furnish the current for light and power. In arranging the insertion tables the use of dynamos inserted parallel has been kept in view.

The lamps of different illuminating power, the installation of which, in the houses of subscribers, is about to take place, consume altogether 32,000 watts. As motive power 60 H.P. have been already distributed, and the alternating current motors required by the different subscribers are being distributed within the common conductive net, or placed branching off parallel to the secondary leads as well as the lamps.

The completion of this installation, which promises to be very interesting, is being pushed forward very diligently and is expected within a few weeks.

UNITS OF MEASUREMENT OF PHYSICAL QUANTITIES.*

By W. M. MADDEN.

IT is proposed in this paper to investigate the relations holding between the units employed to measure physical quantities when two suppositions are made in addition to those on which the ordinary equations of this kind are founded, these two suppositions being, that the unit of force shall be the force of attraction of two unit masses at unit distance, and that the unit of quantity of electricity shall be the same, whether measured by the electrostatic or electro-magnetic method.

It will be found that, making these two suppositions, the changes necessary in the magnitude of the units of all physical quantities can all be expressed as powers of the change made in the unit of time which will remain the one independent variable.

It will appear, however, that the system so obtained will give us enormously large quantities for most of our units, unless, indeed, we make our unit of time exceedingly small, in which case some of the other units may be diminished, though others will be still further increased, and many will remain unaltered.

For this reason it would not be convenient to make use of such a system in practice, nor, indeed, of any system capable of being derived from it; and it is only put forward as having a certain theoretical interest on account of its reducing the number of fundamental units from three to one.

There is another reason why such an investigation is worth making. There seem to be a number of people (it would be easy to justify this statement by quotations) who see in the equations connecting the derived units with the fundamental something more than numerical formula convenient for purposes of changing from one system of fundamental units to another, who regard the symbols [W] [L] [T], &c., not as numbers, but as physical entities, and imagine that the equation $P = M L^2 T^{-3}$, or as they, perhaps, prefer to write it, $[P] = [M] [L]^2 [T]^{-3}$, asserts that *power* is the product of *mass* into *area* divided by the cube of time (whatever that may be). Possibly some of these philosophers may be disposed to reconsider the arguments by which they have persuaded themselves to this effect, when it can be shown that by introducing certain restrictions on the choice of units (quite as allowable as that which determines the unit of velocity at present) they are forced by parity of reasoning to the conclusion that energy, mass, electricity, &c., are all simple algebraic functions of time only.

This main proposition is easily proved; the investigation showing that $M = L^3 T^{-2}$ on the first hypothesis is generally known: it is also known that the ratio of the electro-magnetic to the electrostatic unit of quantity is a velocity; that the two units may be the same this velocity must be always equal to unity, or $L = T$, which taken with the other equation gives us $M = T$ also, so that our three units must all vary in the same ratio when any change is made. By applying this to the ordinary table of dimensions of units we get the following table which has, at least, the merit of simplicity:—

Kinematic and dynamical units.	Electric units.	Magnetic units.
$L = M = T$	$Q = T$	Strength of pole ... ... $= T$
$V = T^0$	$C = T^0$	Potential .. .. $= T^0$
$a = T^{-1}$	$E = T^0$	Intensity of field ... ... $= T^{-1}$
Momentum $= T$	$R = T^0$	Magnetic moment ... $= T^2$
$F = T^0$	$Cp = T$	Intensity of magnetisation $= T^{-1}$
$W = T$		
$P = T^0$		
Density $= T^{-2}$		

From this table we see that many of our units will remain unchanged whatever the unit of time, and the rest for the most part are changed in the same ratio as the unit of time. Acceleration, density, and some of our magnetic units being the exceptions.

It may be interesting to consider approximately what these units will be taking a second as the unit of time, and also whether any unit of time can be chosen which will reduce some of them to reasonable dimensions (it is clear that they cannot all be so reduced, for while some are independent of the time others would be increased by the change and others again diminished).

Taking the velocity above determined to be 2·9857 × 10^{10} cm. per second, we have for our unit of length 29,857 × 10^6 cm., or 298,570 kilometres. At this distance, then, the units of mass must be placed, and the stress between them must be sufficient to produce in each a velocity equal to the velocity of light in one second, that strain being due to their mutual attraction.

Roughly speaking, the distance between the masses is two-thirds that between the moon and the earth. At that distance the acceleration due to the earth's attraction is decreased in the ratio of $\left\{\frac{1}{40{\cdot}2}\right\}^2$ *i.e.*, will be $\frac{981}{(40{\cdot}2)^2} = {\cdot}607$, whence it follows that the unit of mass will be $\frac{2{\cdot}9857 \times 10^{10}}{{\cdot}607} = (4{\cdot}92 \times 10^{10})$ times the mass of the earth. Two such masses together would contain the mass of the sun nearly as many times as the mass of the sun does that of the earth. Any nearer approximation to the actual value is for present purposes unnecessary.

[In grammes this mass amounts to $4{\cdot}92 \times 10^{10} \times 6{\cdot}04 \times 10^{31} \times 1{\cdot}016050 = 3{\cdot}02 \times 10^{38}$.]

The actual values of the other units can be calculated directly from these results; thus for quantity we have $Q = L^{\frac{1}{2}} M^{\frac{1}{2}} = \sqrt{2{\cdot}9857 \times 3{\cdot}02 \times 10^{38}} = 3{\cdot}0028 \times 10^{17}$. E.M. units of quantity $= 3{\cdot}0028 \times 10^{18}$ coulombs.

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* For introductory remarks see Mr. Madden's letter.—EDS. ELEC. REV.

$$\text{E.M.F.} = L^{\frac{3}{2}} M^{\frac{1}{2}} T^{-2} = 3{\cdot}0028 \times 10^{18} \times 2{\cdot}9857 \times 10^{10} \text{ C.G.S. units.}$$
$$= 3{\cdot}0028 \times 2{\cdot}9857 \times 10^{28}.$$
$$= 3{\cdot}0028 \times 2{\cdot}9857 \times 10^{20} \text{ volts.}$$
$$R = L T^{-1} = 2{\cdot}9857 \times 10^{10} = 29{,}857 \text{ ohms.}$$

Next reducing our unit of length to ·0005 mm. and making the corresponding alteration in the unit of time, we arrive at the system suggested by Clerk Maxwell, in which the unit of space is the length of a wave of light of some special refrangibility, and the unit of time the corresponding period of vibration.

This change will, as before said, leave many of our units unaltered, but that of mass will be reduced in the same ratio as that of length, *i.e.*, divided by $\frac{2{\cdot}9857 \times 10^{10}}{{\cdot}00005}$, *i.e.*, by $5{\cdot}9714 \times 10^{14}$, and becomes equal to $\frac{3{\cdot}02 \times 10^{38}}{5{\cdot}9714 \times 10^{-14}} = 5{\cdot}057 \times 10^{23}$ grammes, somewhat less than the thousandth part of the mass of the earth.

Q = nearly 5,000 coulombs.

While R, C, E, remain unaltered.

LONG-DISTANCE POWER TRANSMISSION FROM OVER-COMPOUNDED GENERATORS.*

By LEMUEL WM. SERRELL, M.E.

IF all persons were possessed of the latent power a gentleman from Boston gave proof of in one of our sister States in the South a few months ago, it would be unnecessary for engineers to spend time developing the scientific transmission of power, as every one would be a walking power-plant himself. But as all do not claim such inherent sterling qualities, engineers have been compelled to have recourse to mechanical means for transmitting power, and among the principal ones may be mentioned:

The cable, or moving rope.

Compressed air, operating air motors.

Steam, distributed through pipes, to prime movers, variously situated.

Gas, both natural and artificial.

Water, forced through pipes under pressure, operating water moters, and

Electricity.

Most people are willing to admit that electricity applied for power purposes offers far greater facilities in ease of management, rapidity of construction, most economical operation, and, consequently, a better commercial investment than any of the other methods mentioned.

The constant potential method of distributing power will, in the present state of the art, give better satisfaction than either the constant current or alternating systems, although much may be expected from both of these, especially the latter, when brought to a better state of perfection through future development.

Popular opinion is greatly agitated at present over the danger to life, occasioned by the use of high pressure currents, and it really seems as if popular prejudice would shortly seek legislative protection from the deadly wires, and ask some of our intelligent law makers to establish a limit to the number of volts that may be used for commercial purposes. Where would steam engineering be to-day, if its development had been hampered by laws forbidding the use of pressures of over 25 lbs. in steam boilers, for fear of terrible explosions and casualties to life? Engineers have found high pressures and greater expansions more economical than low pressures, and while there have been explosions, and people killed, yet to-day pressures of several hundred pounds are used with impunity, in consequence of the principles of the resistance of materials being properly applied. The day is not far distant when ten thousand volts will be handled as safely as the high pressures now employed in our steam engines.

Where power is transmitted from a distance and distributed in one place, the dynamo should be over-compounded to maintain a constant difference of potential at the motors under varying loads. This requires a specially proportioned winding on the generator, to lay out which the resistance of the external circuit must be accurately known.

Three things should be considered in detail in planning such an installation:

1. The motors.
2. The line and the method of distribution.
3. The generator.

To more clearly understand these, let us consider their relations to a practical example in detail.

Example: Required the total cost of dynamos, motors and copper necessary to transmit 100 H.P. to motors 5,000 feet away under a pressure of 1,000 volts at the motor terminals, and a loss of 20 per cent. in the line.

If a constant E.M.F. can be maintained at the motor terminals, any of the best motors on the market will work satisfactorily if properly installed.

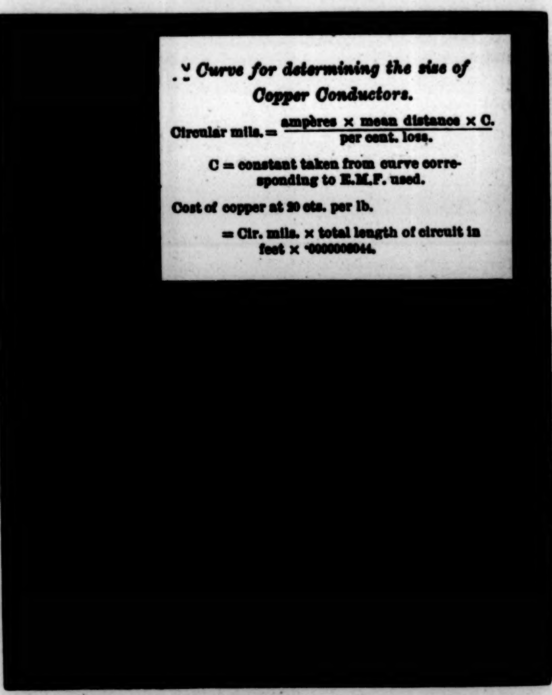

FIG. 1

In considering the line work and the methods of distribution, fig. 1 shows a curve for determining the size of wire to use, to carry a given number of ampères with a given per cent. loss; the abscissæ represent various voltages from 110 to 1,500 volts, and the ordinates the corresponding constants, which, when multiplied by the mean distance, or one-half the total length of the circuit in feet, and the number of ampères to be transmitted, and divided by the per cent. loss, give the size of the wire in circular mils. That is:—

$$\text{Circular mils} = \frac{\text{ampères} \times \text{mean distance (feet)} \times C}{\text{per cent. loss.}}$$

Figs. 2 and 3 show practically the conditions existing in the foregoing example. Fig. 2 shows the dynamo supplying current to one large motor, situated 5,000 feet away; while fig. 3 shows a method of distribution that can be used where power is to be distributed in small units throughout a district. In fig. 2 a horizontal turbine, provided with a governor to maintain a constant speed, drives a dynamo from which the line circuit extends to the motor. This dynamo is over-compounded for the resistance of the armature, the series coil and the external circuit, and maintains a constant electromotive force at the motor terminals under all variations of load. Fig. 3 shows the same general arrangement of turbine and dynamo with the feeder wires extending to a district station and connected to the "bus" wires, upon which a constant potential is maintained by the over-compounding of the dynamo. Where high-pressure generators are used it is very expensive to wind a shunt-field of high enough resistance to stand the electromotive force of the armature; it is much cheaper to wind a shunt-field for a low pressure of, say, 110 volts, and separately excite it by a small constant potential dynamo driven direct from the turbine.

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* *Electrical World.*

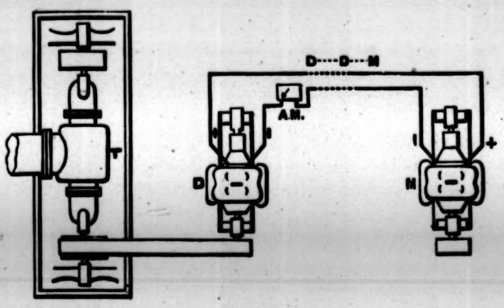

FIG. 2.

T Turbine; D, Dynamo; M, Motor; A M, Ampère Meter; D D M Distance from Dynamo to Motor, 5,000 feet.

the voltage of the dynamo must be 1,250 volts at full load, there being a loss of 20 per cent. in the line. Assuming the efficiency of the motors to be 90 per cent., they must be supplied with 111 H.P., or 82,800 watts, which at 1,000 volts gives 82·8 ampères.

Referring to the curve, fig. 1, we find the constant for 1,250 volts is 1·83, and the

$$\text{cir. mils.} = \frac{82{\cdot}8 \times 5{,}000 \times 1{\cdot}83}{20} = 37{,}875.$$

Multiplying 37,875 (the cir. mils.) by 10,000 (the length of the circuit in feet), by ·0000006044, gives the price of the copper at 20 cents per pound, equal to $228.92.

To construct a cumulative dynamo to maintain a constant E.M.F. at the motor terminals, it should be over-compounded for the resistance of the line, the series coil of the dynamo and the armature. Suppose that the resistance of the armature and the series coil together is one ohm, the drop at the dynamo terminals, due to the internal resistance of the dynamo, would be 82·8 volts. Therefore, to maintain a constant potential at the dynamo terminals, irrespective of the external circuit, we would have to proportion the ampère turns of the series coil so that the increase in the strength of the field would be such that the armature would develop 1,082·8 volts when supplying 82·8 ampères, the speed remaining constant. The line, A B, then, in fig. 4, would represent the voltage at the dynamo terminals under varying loads if the series coil had no effect at all, while the line, A E, would represent the number of volts actually developed in the armature when the series coil is proportioned to maintain a constant E.M.F. at the dynamo terminals of 1,000 volts, as shown in line, A D. The shunt field should be of such strength that the armature will develop 1,000 volts on open circuit, while the series coil will cause the armature to develop an increased number of volts, represented by ordinates included between the lines, A E and A D, corresponding to their respective ampère loads. Now, if the dynamo is over-compounded so as to maintain a constant E.M.F. of 1,000 volts at the motor terminals, it must be over-compounded for the resistance of the external and internal circuits, and the ordinates between the axis of X and the line A C would represent the voltage at the dynamo terminals under varying loads, while the ordinates between the line, A C and A D, would represent the compounding necessary to make up for the losses in the external circuit. But the ordinates included between A E and A D represent the compounding necessary to make up the losses in the internal circuit; therefore, the total compounding necessary to maintain a constant E.M.F. at the motor terminals would be the sum of the two; and, adding the ordinates of the triangle, A D E, to the respective ordinates of the triangle, A D C, we obtain the line, A H, which represents the total number of

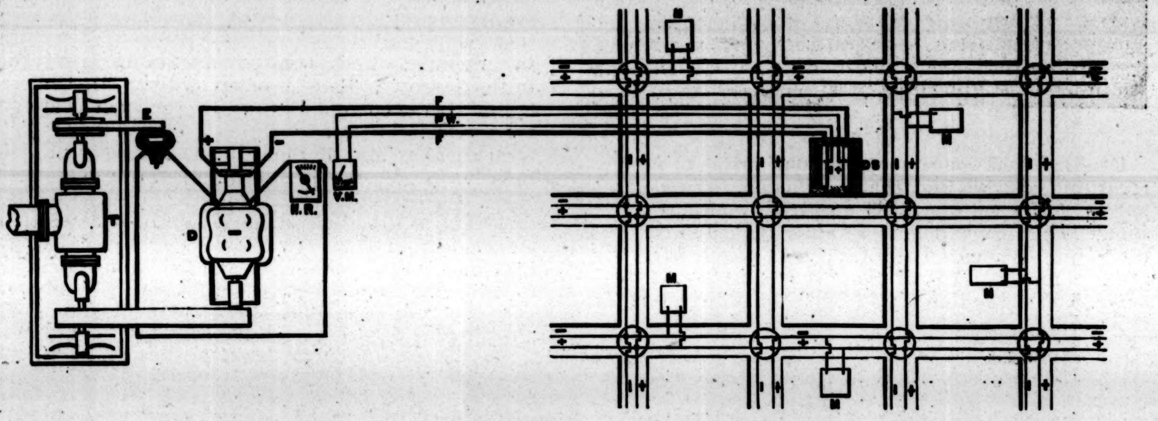

FIG. 3.

T, Turbine; D, Dynamo; E, Exciter; H R, Hand Reg.; V M, Voltmeter; F, Feeders; P W, Pressure Wires; M, Motor; D S, Distant Station.

Pressure wires should be run from the "bus" wires in the district station to a voltmeter in the main generating station, so that the pressure at the district station may be read at any time by the attendant in the main station. If for any reason this pressure should vary, a hand regulator should be provided in the shunt field circuit of the generator to regulate the pressure at the district station.

By using the "box" or "crib" system of wiring, a large district may be wired for a small initial cost, having scarcely an appreciable drop of potential and needing no equalisers. This is effected by connecting the positive wires together and the negative wires together at each junction box, thus forming a network of positive and a network of negative wires. Should a particular portion of the circuit be overloaded the current can flow through all the wires in both the positive and negative networks, and supply all the current needed with scarcely a perceptible drop of potential. It also allows a larger district to be wired for the same initial cost of copper than could otherwise be covered.

Referring once more to the example, we find that dividing 1,000, the voltage at the motors, by ·80, that developed in the armature under varying loads. Now, if it took 1,250 ampère turns of series coil to cause an increase in the strength of the field sufficient to overcome the drop in the internal circuit only, and maintain a constant E.M.F. at the dynamo terminals, the series coil would have 15 turns of a wire. To maintain a constant E.M.F. at the motor terminals, the ampère turns would be proportional to the increase in the voltage; or we should have

$$82{\cdot}8 : 332{\cdot}8 :: 1{,}250 : x,$$

or $x = 5{,}145$ ampère turns, which would require 62 turns of wire in the series coil, provided the machine was working below saturation and the shunt-field separately excited. If, however, the shunt-field is excited by the generator itself, the increase of ampère turns in the shunt-field, due to the increased current flowing through it under the higher voltage, should be subtracted from the total number of ampère turns obtained above, and a series coil laid out having a number of ampère turns equal to this difference.

FIG. 4.

Coming back once more to our original problem regarding cost, we find that a dynamo, having an output of 1,250 volts and 83 ampères, would represent about 140 H.P., which, at $45 per H.P., a fairly close figure for dynamos built for 1,200 volts, would cost $6,300; for 100 H.P. of motors, at $50 per H.P., we have $5,000; the line costs $228.92, making a total of:

Dynamos	$6,300.00
Motors	5,000.00
Line	228.92
Total	$11,528.92

This figure does not include any construction work, but gives an approximate idea of the cost of the electrical equipment, which would of course vary somewhat according to the number of people bidding for the contract.

ON THE HEATING OF WIRES AND LAMP FILAMENTS.

By GILBERT S. RAM.

THE law of the heating of conductors by current, which for a given rise in the temperature of the conductor, gives current $\propto$ diameter $\sqrt{\text{diameter}}$, was very clearly set forth in the ELECTRICAL REVIEW in 1882,* and has since been the subject of very careful experimental investigation by Prof. Forbes, Mr. Preece, and others. The law is arrived at in a very simple manner. It assumes that the loss of heat from a conductor is proportional to its surface, or what amounts to the same thing, the loss of heat per unit of surface is constant for all sizes. When a constant temperature is arrived at, the loss of heat must necessarily be equal in amount to the heat generated in the conductor. Therefore,

$C^2 R \propto$ surface $\propto d$

and $$R \propto \frac{1}{d^2}$$

$$\therefore \frac{c^2}{d^2} \propto d$$

and $$\therefore c \propto d^{\frac{3}{2}}$$

and inversely $$d \propto c^{\frac{2}{3}}$$

That is to say, in order to maintain a given temperature (1) in conductors of different diameter, the current in each must be proportional to $(\text{diameter})^{\frac{3}{2}}$, or (2) with different currents the diameters must be proportional to $(\text{current})^{\frac{2}{3}}$.

The assumption that the loss of heat is proportional to the surface is, however, only true in certain cases. A conductor may loose heat in three ways: by conduction through its extremities, by convection and by radiation. The loss of heat is strictly proportional to the surface, only when radiation is the ruling factor. Short lengths of wire are very much affected by the cooling through large terminals, as in the case of ordinary "cut-outs." The experiments of Mr. Preece, who used the same pair of massive terminals and the same length of wire in each case, show that the constant, a, ($c = a\, d^{\frac{3}{2}}$) can scarcely be called constant under these conditions. Convection does not seem to be proportional to surface. Therefore the only case where this law can be strictly true, is when the conductor is of considerable length compared with its diameter, or the supports are very small, so that the conduction from the ends is a very small proportion of the total loss of heat and when there is no convection. That is, the conductor must be in a vacuum. These conditions are very nearly filled in the case of a filament of an ordinary incandescent lamp. Large current lamps, however, such as are made for series lighting, and which require large radiating lumps at the joint of the carbon and leading-in wires, in order to keep the joint cool, must, if the filament is short, be an exception; the radiating lumps acting in the same way as the binding posts of a safety cut-out. The writer has found this law of great use in calculating the diameters for lamp filaments, and some time ago in order to ascertain how close the actual results were to the calculated values, he took very careful measurements of 30 lamps. The lamps were taken from six different batches and tested at 3 watts per C.P. by three different observers.

Lot 1	8 Lamps.	111 Volts.	22·5 C.P.	7 Mils.
2	9	102	22	7·3
3	3	93	26	8·5
4	5	52·5	22	11·5
5	4	74	37·5	13
6	1	76	68	19

The following curve is from the equation

$$d = a\, c^{\frac{2}{3}},$$

a is taken from the No. 1 lot of lamps and $= 9{\cdot}73$.

The crosses mark the position of each batch of lamps, as determined by the actual measurements of the current and diameters. It will be seen that the actual results lie very close to the calculated, showing that lamp filaments, at any rate within these limits of diameter, certainly do follow the $C^{\frac{2}{3}}$ law, and that the radiation per unit of surface is the same for all these diameters. Although, at the time, the writer did not take any observations below 7 mils., he has since done so as low as 5 mils., and found the same agreement between the calculated and observed values. By means of this law it is thus very easy to estimate the correct diameter for a filament of an incandescent lamp of any voltage and candle-power. A different constant will, however, be required for different efficiencies. In order to make a lamp of certain volts and C.P. at a certain efficiency, it is only necessary to calculate the current which the lamp will take, and the equation $d = a\, c^{\frac{2}{3}}$ gives the diameter which must be used. The length of the filament is given by the equation $l = b \frac{C P}{d}$, where b is another constant. If a filament is then selected of the diameter given by the first formula and mounted to the length given by the second, it will be found to test very closely to the volts and C.P. required at the required efficiency.

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* "Electric Lighting by Incandescence," by H. R. Kempe.

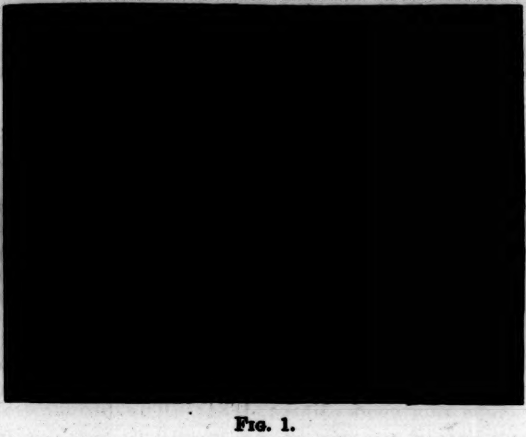

FIG. 1.

Both the constants, a and b, can be determined at the same time and for all efficiencies, from measurements taken from one or more lamps. Their value depends on the nature of the surface of the filament—its emissivity, its specific resistance, the temperature, *i.e.*, watts per C.P.—and the units employed. Of course, the same constants will only be applicable to filaments made by the same process. This method of calculating the size of a filament is only really useful in the case of filaments which do not require flashing; although it may be used to indicate about the size to give to a flashed filament. When the process of flashing is resorted to it gives a wide range to the possible diameter of a filament. The emissivity may be made to vary very much—as much as 50 per cent.—and what might be called the specific resistance of the filament, may be reduced any amount down to, at any rate, $\frac{1}{4}$th. It is thus quite possible to have two filaments of exactly the same length and diameter and at the same temperature (*i.e.*, same watt per C.P.), yet giving a very different amount of light. Or, to put it another way, two filaments may give the same C.P. at the same volts and efficiency, and yet be of very different dimensions. So very largely are the emissivity and resistance of a filament changed by flashing, even when done very slowly and in an exceedingly rarefied gas, that it is easier to get lamps uniform one with another by simply selecting the filaments by measurement than by attempting to make them all alike by flashing.

With a really good filament the only advantage of flashing is that the same diameter of filament may be made to do duty within certain limits for different currents. As a flashed filament has usually a much smaller emissivity and a lower resistance than an unflashed one, it must be longer to give the same C.P. at the same volts and efficiency, and as certain users of the electric light will insist that they get more light from a long filament than a short one—no matter what its emissivity and diameter may be—it might in such cases be considered wise to make filaments as long as possible. The remark, however, does not apply at the present time in this country, as customers have no choice. If the filament is inferior to start with—for instance, if it shows bright spots or otherwise lights up unevenly—of course flashing is advantageous in correcting these faults, as also it is if the filament is soft, for it may then be given a hard coating of flashed carbon, which will protect it from disintegration.

In many cases it is quite possible to have the same diameter for a flashed or unflashed filament for the same volts, C.P. and efficiency. Take the case of a 100 volt 20 C.P. lamp at 3 watts per C.P. It would be 167 ohms resistance, and wonld take ·6 ampère. The diameter in a certain make of carbon would be 7 mils., and when unflashed would be 4·7 inches long to give the required result. Now this carbon, when flashed, would have its emissivity reduced, say, in the ratio of 14 to 10. Therefore for the same diameter, in order to still give 20 C.P., it must be lengthened to $4{\cdot}7 \times \frac{14}{10} = 6{\cdot}6$ inches. It will have now a correspondingly increased resistance of 234 ohms; but, by the flashing, this may be reduced to 167 ohms, and without perceptably increasing the diameter. Therefore 6·6 inches of this filament when flashed will be the exact equivalent of 4·7 inches unflashed.

The process of flashing does not, as is sometimes supposed, deposit carbon in the pores of the filament. A good filament practically has no pores. It is only an exterior coating which is deposited.

There is on this account a disadvantage in flashing in the case of very thin filaments, such as must be used for low C.P. high volt lamps. When the current is switched on to one of these lamps suddenly, it frequently happens that a small portion of the flashed deposit, perhaps $\frac{1}{30}$th inch long, will be detached, and in a quiet room a distinct click may be heard when this happens.

On examining the lamp a gap in the flashed coating will be seen, the original black filament showing through. A bright spot is formed here where the filament will soon break. Probably the filament proper becomes hot and expands before the flashed coating, and to such an extent as to cause the coating to break. At any rate, it does not occur in lamps with thick filaments, which take an appreciable time to get hot after the current has been turned on. This is a fruitful cause of breakage in flashed filament lamps of say 100 volts, 8 C.P.

An unflashed filament with a highly polished black surface, which at 3 watts per C.P. gives, say, 14 C.P., if very slightly flashed, just enough to make the surface appear white instead of black, and without any perceptible thickening, and still retaining its polished appearance, will now at 3 watts per C.P. give only 10 C.P. There is a still greater difference in emissivity between the white shiny surface and a black dull surface, such as is often seen in the filament of a lamp which has been running a long time, and it is this which causes the greater part of the falling off in light of old lamps. A flashed filament with a smooth whitish surface, after a certain length of time, gradually loses its polished appearance, and eventually turns to a dull black, with the result of increasing its emissivity perhaps 50 per cent. As the amount of heat now generated in the filament is certainly no more than it was originally, it will be radiated much more freely, and therefore at a much lower temperature. The other, and usually lesser, causes of the falling off in C.P. are the blackening of the globe by particles of carbon thrown off from the filament and the consequent rise in resistance of the filament due to this throwing off.

Mr. Preece, in a lecture before the Royal Society, December, 1887, gave the results of numerous experiments he had made to ascertain the current required to fuse wires of various metals in air, both with short lengths of wire, as used in cut-outs, and therefore subject to much cooling from the terminal posts, and with wires six inches long where the terminal cooling was negligible. The wires experimented on ranged from 4 mils. to 40, and for each diameter Mr. Preece gave the value of the constant a, in the equation $c = a\, d^{\frac{3}{2}}$. There is a large variation in the value of a in the case of the cut-outs, as might be expected. And on examining the tables of constants for the 6 inch lengths, they are also seen to vary considerably, especially for diameters below 15 mils. The value of a rises very much as the wires get smaller, below about 15 mils. Mr. Preece has taken the mean, for each metal, of all the values obtained for a, and has calculated therefrom the fusing currents. These calculated values, however do not agree closely with the actual results. In a subsequent lecture, however, a few months later, he gives corrected values for a, which are smaller than the former values, and are evidently obtained by omitting the high values for the smaller wires. The currents calculated from these constants agree much more closely with the observed values, and no doubt give about the correct value. Though from accidental variation in the emissivity or the specific resistance of the different samples of wire or from some other cause, the actual fusing current may differ as much as 20 per cent. from the calculated. This may be readily seen by plotting on squared paper the values calculated from the "final values of a," and the actual values as given. It would seem unnecessary to calculate such constants to five figures.

In a paper also before the Royal Society in April, 1884, Mr. Preece gave the values of fusing currents for very small platinum wires in air, from 0·5 mil. to 3 mils. diameter, and instead of following the $d^{\frac{3}{2}}$ law the currents were almost exactly in direct proportion to the diameters. It is thus evident that even if the $c \propto d^{\frac{3}{2}}$ law is correct for conductors over about 20 mils. diameter in air, it is certainly not correct from that size downwards.

Mr. Bernstein has published an interesting table (*Centralblatt für Elektrotechnik* and *Industries*, March, 1889), showing the energy per unit of surface required to maintain a temperature showing a dull red glow in the dark (526° C.), for platinum wires ranging from 3·55 to 10 mils. under different pressures from atmospheric pressure down to the most perfect vacuum he could obtain. The observations he gives are plotted below.

Curves from Bernstein's Table, showing energy per unit of surface required to maintain temperature of 526° C.

Energy per 0·0155 sq. inch surface in Watts.

FIG. 2.

They show that with a perfect vacuum the energy per unit of surface is precisely the same for all the sizes of wire. This means that the law $c \propto d^{\frac{3}{2}}$ is true, even for these small sizes of wire, when in a perfect vacuum. With a poor vacuum, however, there is at once double the power per unit of surface required in the case of the 3·55 mil. wire as with the 10 mil, while at atmospheric pressure there is $2\frac{1}{2}$ times the amount.

According to this, in the case of two wires of the same length, one 3·55 mils. and the other 10 mils. diameter, at atmospheric pressure, the smaller wire will require energy in the proportion of $3{\cdot}55 \times 2{\cdot}5 = 8{\cdot}9$ units, as against 10 for the larger one, to raise it to the same temperature.

(*To be continued.*)

ON THE HEATING OF CONDUCTORS BY ELECTRIC CURRENTS.*

By A. E. KENNELLY.

I.

ALTHOUGH the best economical dimensions of a conductor employed to transmit power are determined by Sir William Thomsom's law that that portion of the cost rate depending directly upon the cross sectional area of the conductor should equal the average cost rate of the power it absorbs in its duty, and although at the existing prices of copper and of power, such a conductor must be very heavily loaded to acquire a dangerously high temperature; yet not only may its limits of safe capacity be strained by occasional pressure, but it is well known that in practice, economy is not the only factor that determines a conductor's size, since the necessity, for example, of maintaining a constant difference of potential over an entire network of electric light mains under wide variations of load, may sometimes clash with the conditions of economy in their transmission, or even of safety in their temperatures.

Notwithstanding the consequent importance of a complete knowledge of the safe carrying capacity in conductors under all practical conditions of service, the subject has not, apparently, received the attention it deserves, and the simplicity of the law which determines the generation of heat in an active conductor, seems to have caused the complexity of the laws governing the dissipation of that heat, and thus the limiting temperature, to escape the full notice of practical men. The most important published contributions to the subject appear in two papers, one by Mr. W. H. Preece, to the Royal Society, in March, 1888, and the other by Prof. G. Forbes, to the London Institution of Electrical Engineers (March, 1884). The former deals principally, however, with the fusing currents of wires for different metals and diameters, while the latter is almost exclusively devoted to the theoretical treatment of the subject. Had the experimental data of Prof. Forbes's paper been as exhaustive as its mathematical investigation was complete, there would probably have been little left to add or amend from an engineering point of view; but the vital numerical coefficients it adopts are taken from experiments on the emission of heat, which, however accurate and valuable in themselves, are not fairly applicable to the conditions of conducting wires, and which, in their published form, tend rather to conceal than to elucidate the principles underlying the subject. The fact remains that none of the existing text books or tables up to the present date give, with any pretension to accuracy, the carrying capacity of wires consistent with safe temperatures, in clearly tabulated form, or any clear conception of the variation the limit undergoes with change of environment empanelled, free, or out of doors. In addition to this, the rule of the British Board of Trade for installations within doors has been pointed out by Prof. Forbes and others to be very uneconomical for small wires, and actually unsafe for wires of a certain, though perhaps unusual, diameter.

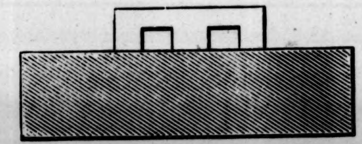

FIG. 1.

To determine some of these unknown quantities, and particularly with a view to obtaining the necessary data for the fire insurance offices, the Edison Electric Light Company, of New York, recently instituted a series of experiments at the laboratory of Mr. T. A. Edison, in Orange, N.J., and with their permission the results obtained are now published. Not only have satisfactory general rules been arrived at for the safe carrying capacity of conductors, but the numerical coefficients in the formulæ given by Forbes have been determined with a fair practical degree of accuracy, while the field has been opened for further useful investigation.

The experiments were made on conductors under three different conditions :—

1. With insulated copper wires encased in wooden panelling to represent house wires.

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* Abstract of report read before the Edison Convention at Niagara Falls, August, 1889, and published in the *Electrical World*.

2. With copper wires, both bare and covered, suspended on poles in the open air to represent overhead service.

3. With copper wires and strips suspended across a room to represent the conductors in an electric light station, and also to form a connecting link between the two previous conditions.

The elevation of temperature produced in the wires (whose conductivity varied from 97 to 101 * per cent.) was in every case determined from the increase of their resistance observed after the experimental current had been passed through them sufficiently long to practically attain a limiting permanent temperature. This period of time was found to be about ten minutes with the panelled, and some two minutes with the suspended wires. With the former, a steady increase of resistance, which, according to theory would continue for all time, could be noticed for as much as 30 minutes, but it was estimated that the temperature elevation reached in ten minutes was 97 per cent. of its full ultimate value, and the greater accuracy attained by longer intervals of flow would not have repaid greater loss of time, especially as the quality of the wooden panel, its thickness, form and position, would practically involve commensurate variation in results.

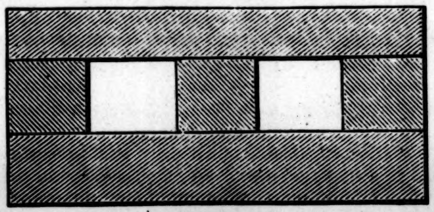

FIG. 2.

It has been sometimes believed that the temperature elevation computed from the rise of resistance would be somewhat in defect owing to the gradient of temperature from the centre to the circumference, and the cooling of the external surface. Analysis shows, however, that this source of error is too trivial to be taken into account, for if θ be the difference of temperature in degrees Cent. maintained in the permanent state between the axis of a wire and its exterior, then it will be found that

$$\theta = \frac{\rho}{\text{J K}}\left(\frac{\text{C}}{\text{O}}\right)^2;$$

where ρ is the resistivity of the wire,
C is the current it carries,
O is its circumference,
J is Joule's equivalent, or 42 megalergs,
K is the thermal conductivity of the metal,
all being expressed in absolute measure.

For a copper wire of 1 centimetre in circumference, carrying 100 ampères with ρ = 2,000 and K = 1·1, $\theta = \frac{1}{220}$ of 1 degree Cent.

EMPANELLED WIRES.

Two 20-foot lengths of pine panelling were made of the cross sections represented in figs. 1 and 2, and in all the tests these panels rested with their broad bases on the wooden floor of the testing room. In the smaller size, 12 wires, ranging from 0·0185 inch (0·047 centimetre) to 0·119 inch (0·302 centimetre) diameter, were successively tested, one side only of the panel being occupied at one time. In the larger size, 12 larger wires were tested, ranging from 0·119 inch (0·302 centimetre) to 0·445 inch (1·131 centimetres) diameter, generally two at one time, one in each compartment, so that the observations may be said to extend to diameters of nearly half an inch, or from wires whose resistance per metre varied from 0·019 ohm to 245 microhms at zero C. All the resistances in the tests are expressed in legal ohms (106·0 centimetres).

The increase in the resistance of the wires due to their heating was determined in the cases of all but the very smallest by that very accurate null method, in which the variable potential difference between the ends of the tested wire is balanced against the constant potential difference between the ends of an invariable platinoid resistance in the same main circuit, as shown diagrammatically in fig. 3. This standard resistance was formed by a grid of 40 parallel platinoid wires, each eight feet (244 centimetres) long and 0·031 inch (0·79 centimetre) in diameter, stretched in a wooden frame between copper rods. The joint resistance of all these wires was 0·0499 ohm, and their large total surface of 374 square inches (2,410 square centimetres) and small coefficient of temperature variation (0·21 per cent. per degree C.) effectually maintained the resistance constant within at least 0·1 per cent. under all current strengths employed, especially as with the stronger currents the grid was connected with its two halves in multiple by letting the current enter at a third copper rod in the centre and divide among the forty wires on each side, the total resistance in this condition being 0·0121 ohm.

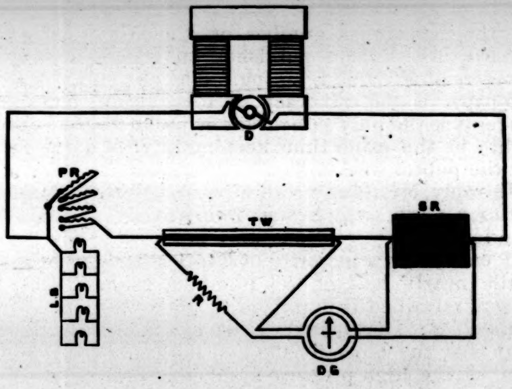

FIG. 3.

D, dynamo; P.R, platinoid resistance; L.B, lamp bank; T.W, tested wire in panel; G.R, standard resistance of platinoid wire grating; R, rheostat; D.G. differential galvanometer.

To balance the potential differences supplied by the wire and the grid, a dead beat differential mirror galvanometer was employed. It was carefully adjusted for differential perfection, until five volts with its coils in opposition series produced a barely perceptible deflection. The resistances and balance of the coils (about 2,700 ohms each) were observed before and after each test. During the observations one of these coils was connected with the panelled wire, and the other in opposition with the platinoid grid. The initial difference between the opposed currents thus acting on the needle when the first feeble current was sent through the main circuit, was reduced to vanishing point by inserting resistance in the circuit of preponderating influence. Under these conditions the resistance of the wire became determined, and its terminal potential difference exactly balanced on the galvanometer that from the grid. As the current in the main circuit was successively increased this balance became upset by the corresponding rise of temperature, resistance and terminal P.D. of the wire, necessitating readjustment of the inserted resistance, while the extent of this readjustment supplied all the data for the calculation of the change. This method was found to be very sensitive, and allowed the rise of temperature to be observed in a convenient manner for estimating the approach to limiting permanent state, while all slight variations of the dynamo testing current were eliminated, since their effect was equal and opposite on the galvanometer circuits. The temperature elevation was carried up to 100° C., except in the case of the largest wires.

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* Samples of copper offering a conductivity of as much as 104 per cent. of the original Mathiessen standard are stated to have been produced within the last few years, showing that the value of the standard needs revision under improved forms of chemical and mechanical treatment.

The strength of the current passing in the main circuit through wire and grid from the laboratory 110-volt dynamo was adjusted by platinoid resistances for the feebler currents by banks of Edison lamps for the stronger, and by a set of overhead wires for the strongest of all, the limit reached being 300 ampères. It was measured by means of a potentiometer, connected with the grid and also by at least one ammeter or dynamometer in the main circuit, whose readings were taken as a check upon the former. About one reading of the current per minute was observed, and the mean taken as that of the average current flowing during the period. The potentiometer employed its own working battery, mirror galvanometer, and Clark standard cell. The potentiometer and ammeter are omitted in the diagram.

THE USE OF HIGH TENSION CURRENTS IN ELECTRIC LIGHTING.

IN the November number of the *North American Review* Mr. Edison published an article upon "The Dangers of Electric Lighting." The gist and purport of the paper is the advocacy of low tension continuous currents as the only safe means of producing the electric light; at the same time keeping in view a due regard for the public weal.

In reply, Mr. Sunny read a paper before the Chicago Electric Club, which was followed by a discussion. The following resolutions were proposed by Mr. Sunny, and carried by a majority of 2 to 1 of those who voted, while nearly half of the numbers present, for some reason, refrained from recording their opinion.

Resolved: That it is the sense of the Chicago Electric Club that the objections to and the general condemnation of the high pressure systems of lighting set forth by Mr. Edison in an article in the November number of the *North American Review* are not sustained, and that the growth and popularity of the service furnished by this class of currents are in themselves a contradiction of Mr. Edison's conclusions; and, further, be it

Resolved: That with proper construction and exercise of reasonable intelligence, the high pressure currents are absolutely safe.

In the course of the discussion it was remarked that the cover containing the *Review* wherein Mr. Edison's paper appeared bore in red letters at the top, "The Dangers of Electric Lighting; by Thomas Edison," and consequently the matter was simply an advertisement of Edisonian wares and theories. The above resolutions, we are afraid, will not escape unfriendly criticism from the opponents of high pressure services.

After remarking that Mr. Edison's paper was a comparatively brief one, Mr. Sunny said: Its statements are sweeping and sensational; it condemns the use of high tension currents, and is worthy of serious consideration for the one reason that it was written by so eminent a man. It has been copied into some of the daily papers, commented on editorially in others, and quite generally discussed in and out of the fraternity. To those engaged in the electric light business the paper comes as a surprise. It is a radical departure from the conservative position held by him for so many years on the subject, for, though the various systems, including the Edison, have been publicly commented on, Mr. Edison has taken no part therein. Inasmuch as the opinions of a man so well known are regarded as of great importance, and, further, as the conclusions set forth by him in this instance are inimical to the interests of one of the most important industries of the country; and as the principal officer of a company likely to be damaged by the expressal of such opinions by Mr. Edison, I think a full and prompt contradiction of the statements made by Mr. Edison should be made wherever they are incorrect or contrary to the general experience, and many statements can be found in the paper to be contradicted. Before touching upon these, however, it may be well to say a few words with reference to the question of overhead wires in New York, the deplorable condition of which is responsible for this utterance of Mr. Edison.

Geographically, New York is about the smallest of the large cities of the Union, and within its narrow limits, particularly those of the commercial district, is crowded an amount of business that is inconceivably great, which exerts its influence throughout the world. Perhaps no better index of its vastness, in a financial way, can be mentioned than the clearing house reports. The volume of business in the principal cities of the United States for one week amounts to $1,137,000,000. Of this sum two-thirds is for New York alone. In the transaction of this business the electric wires play no mean part. They are simply indispensable, as is evidenced in the general suspension of business on the Stock and Produce Exchanges, whenever by reason of great storms the service is interrupted. Without the telegraph and telephone, the ticker, and other electrical adjuncts, business must come to a standstill. It cannot be said that the electrical people have not tried to furnish enough wires for the various demands. They have tacked them up everywhere and in every shape, until the sky is streaked with them. I do believe that if it were not for the vigilance of the vestrymen, the steeple of Trinity Church would have been cross-armed and loaded down with them long before now. A few figures will give an approximate idea of the number of wires in use. Thirty-six distinct electric companies, all operating wires fastened on poles or on roofs; 10,000 telephone wires; say 1,200 telegraph wires; untold miles of electric light circuits, arc and incandescent, fire alarms, burglar alarms, private wires, messenger calls and tickers. To this add the wires abandoned by former telegraph companies, by the telegraph companies, &c., for, until recently, there was no particular difficulty to putting up wires for any and every purpose; a set of poles on each side of a narrow crooked street, and if the street were straight it was honoured by two or three sets of poles on either side—the telegraph, telephone, and electric light wires, indiscriminately mixed together on big poles and little ones, old poles and brightly painted new poles. There was good construction and bad, principally bad, for the reason that there was no room to do the work properly. Small poles, designed to carry two wires, were heavily laden with ten times that number. High voltage currents were driven through wires never properly insulated, with the insulation hanging in rags, leaving bare places on the metal to convey the current to any other wire that might come in contact with it; wires owned by nobody, but which had fallen into the streets, twisted round lamp posts or poles to get them out of the way.

Everyone is aware of the weary discussions that have passed on by the authorities and others relating to this subject. The topic has cut a figure of some importance in politics; and in the newspaper world, when news were scarce, it served to fill up with, and the verdict went forth, that all wires must go underground. Some of the companies opposed this, and injunctions, stays of proceedings, &c., &c., became the order of the day, until the whole subject, to the mind's eye, resembles a fourth of July pin wheel, whirling and spluttering around, throwing off a mass in which one can recognise "Subway Commissions," "Falling Wires," "Exploding Manholes," "Boodle," and the "Mayor's Axe." Out of this confusion have come the death of several men through falling wires, improper construction, or faulty insulation. The shocking death of poor Feeks brought the newspapers of New York, with one voice, to demand the removal of the wires from the streets, and their being placed underground, while the newspapers throughout the land have echoed this opinion and repeated all the horrible details of the unfortunate man's fate. In the midst of this turmoil Mr. Edison's article was launched, and in it we find him more severe than the City administration or the Press. He not only wants the wires removed, but does not want them placed underground; for, as he states, they are more dangerous there than on poles. The reason will be referred to later on.

His article begins with the statement that he speaks on the subject of high pressure wires as "one convinced," and proceeds to classify the various electric currents used as follows :—

1. Low tension continuous current, with a pressure of 200 volts, used for incandescent lighting. This is the current used by the Edison Company, which is largely owned by Mr. Edison, and he says it is safe.

2. High tension continuous current, of 2,000 volts or over. This is not used by the Edison Company, and Mr. Edison says it is "dangerous to life."

3. High tension semi-continuous current with a pressure of 2,000 volts or over, used for arc lighting. The Edison Company does no arc lighting, and Mr. Edison says that "momentary contact with a conductor" carrying this current results in paralysis or death. Of course Mr. Edison did not mean to make a statement so palpably erroneous, but nevertheless, it has gone forth, without the slightest qualification from him as to the conditions that must necessarily exist before a "momentary contact" with a wire of this kind is dangerous.

4. The alternating current, with pressure of 1,000 to 3,000 volts for incandescent lighting, but not used by the Edison Company. This current, Mr. Edison says, produces instantaneous death. Therefore, there is but one safe current, that used by the Edison Company for central station incandescent lighting and which can be used by several other companies, who, however, do not use it, for reasons that I will refer to later.

These are Mr. Edison's classifications, and in order that the public safety may be secured, according to his view of it, it means this : An abandoning of about 300,000 arc lights and about 400 central stations furnishing, say, 2,500,000 incandescent lights by the alternating system, in this country alone, about 2 per cent. of which are in New York, and for what ? Because of the mistakes that have been made in construction, by both the corporate and municipal management, in that little patch of earth called New York city.

Mr. Edison's reason for opposing the placing of high pressure wires under ground is that there is no known insulation that will confine this class of currents for more than a limited period, and then earth contacts will result ; and attendant disaster.

In connection with this statement it must be borne in mind that up to within a few months no high pressure wires were put underground in New York, and that Chicago was the only city undertaking to furnish service in this manner. Mr. Edison's statement, therefore, can only be based on surmise, and not on actual experience, for we have found the working with conductors in conduits in Chicago give every satisfaction, and with no more disastrous result than an occasional defective joint, which was rapidly and readily repaired. The cable also appears to be in perfect condition after two to three years' wear.

Mr. Edison says there is no justification for the use of high potential currents, "either in the scientific or commercial sense." He is not, however, supported in this view, either by the public, the electric people, or his fellow stockholders in the Edison Company. Mr. Edison says it is used to avoid the large expenditure for real estate and copper called for by the low tension system, for the reason that the station using the latter must be put in the centre of the district lighted, while if the high pressure system is employed cheap land at a considerable distance will answer the purpose as well. This is not a fair statement, because the first cost of the plant is in many instances disregarded entirely, and the cost of operation made the important question. The high pressure system permits the placing of the central station at any part of the city, so that coal can be unloaded directly from the waggons ; so that water can be had for condensing engines—two items alone that mean a saving of 40 per cent. in the cost of operation. The loss of electrical energy, amounting to 20 per cent. or more in the Edison system, is considerably reduced by the use of the high pressure system ; while the crowning feature of the latter is the adaptability and practicability for lighting unlimited territory, including the residence district and the suburbs. All this can be done from one central, and at a cost that makes it possible to gauge the price, so that it costs no more for a good electric light than for an indifferent gas jet. That the Edison system is limited in the area over which it can work, this is shown positively from there being three central Edison stations in New York which do not cover more than a fifth part of the city. In Chicago, the Edison Company covers about half a mile in each direction from the station, but some of the most important streets and public buildings are without the radius of their operations.

The Edison system is expensive, because of (1) additional cost for coal, (2) non-condensing engines, (3) greater loss of electrical energy in mains, (4) larger original investment to pay interest on, (5) heavier taxes and insurance. So well known are all these facts, that the high pressure systems are in increasing demand all over the country, while the Edison system starting with a practical monopoly has ceased, so to say, to be an important factor in central station lighting.

It is stated that a 16-candle lamp cannot be furnished under 1 cent per hour, that the Edison people charge 1 and ⅛th cents per hour, equal to gas at $2.40 per 1,000 feet, and that they pay a dividend of 5 per cent., and their stock is quoted $75 per $100.

The average cost of gas in the large cities is now $1.25 per 1,000 feet, and the price for electricity must not be more than 15 per cent. above that, in order to receive universal patronage and displace gas. Can the Edison system furnish light at this figure, and make a profit ? Not so far as we know, and this is the necessity for high pressure currents, which are in demand, and can be supplied at a profit. Mr. Edison's associates in the Edison Company are fully aware of this, and bought an alternating current system in Europe. The agents of the Edison Company announced that the system would soon be on offer for sale, but it appears that Mr. Edison has objected to it, and says : "Up to the present time I have succeeded in inducing them (his associates) not to offer this system to the public, nor will they even do so with my consent."

Mr. Edison's paper, which is supposed to be the declaration of an expert, and consequently dispassionate and fair, we think does not support this supposition, for the following reasons :—

1. It pronounces the Edison or low tension system safe, and the high tension unsafe.

2. It characterises the companies using high tension currents as "promoters of enterprises which spring into existence with the growth and stability of mushrooms."

3. It carefully avoids any mention of the innumerable safeguards thrown around the so-called dangerous currents to prevent their being in reality so.

4. It asserts that high pressure wires cannot and ought not to be allowed to work underground.

There is strong evidence that they can be worked successfully underground, and it seems strange in contrasting the utter hopelessness with which Mr. Edison regards the question, with his well-known habit of including everything imaginable among the possibilities. *It may be admitted that some of the systems under the conditions that exist in New York are dangerous, but the record outside the city has been tolerably free from fatalities, at least during the last three years.* When all the telegraph and telephone wires are buried underground the great majority of the overhead wires will have disappeared, and when it is recollected that most of the accidents that have occurred in New York during the past six months have resulted from fallen telephone wires crossing electric light leads, it will be seen that the removal of these slender wires will take away much of the possibility of a recurrence of the late disasters. If the few wires required for electric lighting are put well and fully insulated there ought not to be much objection to them, and I do not think that there will be. If, however, the electric light wires are in large numbers on important thoroughfares, and it is advisable to place them underground, it will not be long before enough will be known by every man interested in the electric light service regarding the correct methods of handling these high pressure currents underground, so that there will be no hesitation in so disposing of them.

THE DISCUSSION.

Mr. **WILMERDING**, of the Chicago Arc Light and Power Company, said the longest circuit they had was seven miles in length, and carries a voltage of 2,500 volts; they never have any trouble with the insulation, except at the joints occasionally, and that they had several circuits nearly as long.

Mr. **SPERRY** remarked that he had long struggled with this question of high tension. He well remembered the trouble he had at the first in working underground wires. He bought some lead-covered cable, having insulation only one-eighth of an inch in thickness, and laid it in iron pipes; this operated for about three weeks, when the insulation was found to be pierced in a great many places, and the exterior lead covering was found to be of the same potential as the wire throughout the circuit. During the succeeding 18 months he tried as many as 18 different makes of insulated wires, each one guaranteed to stand any potential; each one gave way. At last he did succeed in getting a wire better insulated than the rest; in the meanwhile, he had looked with longing eyes towards those cities where overhead wires were permitted, and during this period he was further distracted by constantly recurring accidents and fires. Now those difficulties had been overcome, and a breakdown was seldom experienced, and then only through faulty jointing. The electrical engineer of the present day can confidently say that high tension currents can be operated underground both with safety and success.

Mr. **WILMERDING** added to his former statement that he had worked on one of his circuits 87 arc lamps having an average potential of 43 volts each, this pressure was kept up for 5 hours with no damage to the insulation.

The **CHAIRMAN** (Mr. F. B. Badt) called attention to comparative loss in the leads of the three-wire system and of the transformer system; at an average load of 50 per cent. the Edison three-wire system becomes more efficient, as far as the loss in the wires is concerned, just when the alternating transformer system becomes less efficient than at a maximum load; so that there are several things to be considered in comparing the two systems.

It is for the electrical engineer to determine which system should be used in each individual case. What may be well and economical in one case may not be so in another.

Mr. **CUTTER** mentioned that Mr. Ferranti had boldly attacked the high pressure problem in England, that his method was simple, and has practically entered a new field, and he considered the way of encasing one conductor within the other precluded all danger of accidents. Mr. Edison's paper was certainly an advertisement. Looking at the question at issue as an electrician, he thought it ought to be studied from the standpoint of science, and not of the pocket-book of the individual interested therein.

The **CHAIRMAN** said he had been interested by Mr. Cutter's remarks. He had taken up the magazine and showed us the name of Edison on the outside with a mention of his article. The other day he (the chairmen) had received a small pamphlet, and it contained, in large red letters, the name of "George Cutter, electrical engineer." It seemed that every one wished to advertise himself.

After a few remarks from Mr. Sunny, the before given resolutions were proposed and carried.

The Paris Exhibition.—The Edison electric light station at the Champ de Mars has been bought by the Government for the illuminated fountains.

THE ELECTRIC LIGHTING AT THE EDINBURGH EXHIBITION.

THE following are the main particulars of the scheme prepared by the Executive for the electric lighting of this Exhibition to which we referred in our last week's issue. The lighting will be carried out by means of 351 arc lights of 1,000 C.P. each, and 1,350 incandescent lamps of 16 C.P.

The lighting must be completed by the 25th April, 1890, the tenders to state a net sum for 600 hours' lighting, and a rate per lamp per hour for extra lighting, including installation. The committee retains the right of supplying current or light to exhibitors, therefore contractors should have a reserve dynamo power of at least 15 per cent. to meet such requirements, and contractors should quote a price for installing exhibitor's lights, and also a charge for current. The conductors are to be calculated on a basis of 1,000 ampères per square inch of section, and the dielectric is to be of the best qualities of India-rubber, taped or braided. The Executive will provide engine power and shafting, with pulleys of such size as may be required, but no belting for the dynamos.

The lighting is to be subdivided as follows: The machinery hall to have 116 arc lamps, arranged in four circuits, with adjacent lamps in different circuits; the courts in west portion of main building 80 arc lights in three circuits; the third section of the building to have 85 arc lamps in three circuits. Each of these three sections is to have one spare dynamo. The fourth section, which embraces the concert hall and reception rooms, will be lighted either by incandescent or arc lights; for the former 1,350 16-C.P. glow lamps will be required, suspended from the roof, or carried in electroliers, to be arranged in four circuits, with a maximum E.M.F. of 120 volts, controlled from main switchboard. The main leads and branches are to be of the best insulation, equal to that known as ship quality, and having a guaranteed insulation of 300 megohms per statute mile. For the arc system, 30 lamps will be required, on two circuits.

The fifth section embraces the general illumination of the grounds, which will be by means of 70 arc lights carried on masts 60 to 80 feet in height, with efficient raising and lowering gear for three lamps on each. The plan adopted for lighting this Exhibition will be seen to bear a very striking resemblance to that carried out at the recent Exhibitions at Glasgow in 1888 and at Manchester in 1887. And the same mistake is made of placing the power as far as possible from the incandescent lamps. The distance is about ½ of a mile, and the amount of heavy mains required will be very considerable. It is almost too much to ask contractors to go to such expense. A further serious item in the expense due to this cause is the large amount of energy wasted in carrying the current this distance, a margin of at least 15 per cent. being required. This practically means 15 per cent. more consumption of fuel than if the power and the lights were close to one another. The committee, however, append the following note to their specification:—"This specification only refers to direct current lighting, but the Lighting Committee invite offers from contractors or exhibitors of alternating plant for the lighting of the outside *cafés* and kiosks by means of incandescent lamps or other system of illumination, and also as it is intended to proceed with the construction of a lecture hall, &c., contractors or exhibitors should quote for supply mains for, say, 20 ampère current for use at lecture table."

We may add that no one firm will be entrusted with the lighting of all the sections, and that proper provision has been made for the testing of the various sections during a six consecutive hours' run under full load. The specifications have been prepared by Mr. William A. Bryson, of Glasgow, who is the engineer and electrician to the Exhibition.

COMMUNICATIONS FROM AUSTRIA-HUNGARY.

(FROM A CORRESPONDENT.)

THE work of establishing the Vienna-Budapest telephone line, which was delayed in consequence of some unexpected hindrances, has now advanced so far, that by the end of this month (November) the first serious attempts at conversation can be carried out. On November 23rd, technical officials of the Hungarian Telephone Commission were staying in Vienna in order to study the arrangements there, and on the 27th November Austrian officials came to Budapest, in order to compare the apparatus there with those of the Vienna station, and to remove any differences in the construction. Hitherto experiments have been made only along the distances between the various posts, which, of course, do not admit of any conclusion as to the working of the complete line. The experiments at conversation are very difficult, especially as three lines are being laid at once between Budapest and Vienna. During the experiments the workmen have to be placed at different stations along the whole line, 262 kilometres in length, in order to remove any defect as soon as detected; but it is often rather difficult to discover where the fault lies. Nevertheless it may be expected with certainty that the line, which promises to become very important, will be open for use within 14 days.

A few days ago there occurred a peculiar case of poisoning by means of gas, which proves that gas lighting may become dangerous even in houses where no gas is used. In a house in the Liniengasse an entire family of three persons met their death through gas poisoning. The peculiarity of the case is that there was no gas-pipe in the whole house, and the gas can only have found entrance from the street. Some days ago the gas main in the street in question had been under repair, since which, according to the indefinite statements of persons living in this and the neighbouring streets, especially on the ground-floors, the smell of gas had been repeatedly noticed.

Fatalities of this kind have recently and repeatedly occurred in the Zovefstadt (a suburb) in rooms on the ground-floor. A similar case of poisoning by gas, which penetrated from the street into a house where no gas was laid on, occurred three years ago at Budapest, proving fatal to an elderly married couple.

As I informed you at the time, the Salzburg electrical works had resolved to increase their share capital by 200,000 florins, and to erect at Innsbruck an electrical central station worked by steam power, in opposition to the existing electrical works impelled by water-power. For some time the above-named Salzburg undertaking has attempted to raise the needful capital by means of public subscription, and by this opportunity to put on the market the 500 shares remaining available from the first issue. The prospectus, which was printed in the Frankfort, Augsburg, and other German papers, brought forward favourably coloured calculations as to returns, on the faith of which a prospect of heavy dividends was held out to subscribers. But the prospectus and the entire undertaking was commented upon unfavourably by leading journals, especially by the *Frankfurt Zeitung*, and the subscriptions resulted in a complete and lamentable fiasco.

It will be of interest to your readers to learn that last week the first alternating current motor worked by the Innsbruck Electrical Works was set up at the Anatomical Institute, and is in successful action. Further alternating current motors, for which there is now a brisk enquiry, will be erected during the next few weeks.

Yesterday, November 27th, the first official trial conversations took place on the Budapest-Prague telephone line, and proved successful. This is one of the longest telephone lines on the Continent, if not the longest, as it measures over 600 kilometres.

NOTES.

Electric Lighting in Woolwich.—The Woolwich Local Board has decided to grant facilities to Mr. Rahtz, of Messrs. Winter and Co., for letting out electric light to shopkeepers in Powis Street, and has also asked for an estimate for the maintenance of the electric light in Beresford Square.

Electric Lighting (Provisional Orders).—The following is a complete list of the applications :—Airdrie, Acton and Ealing, Aberdeen (2), Aberdare, Ayr Burgh, Accrington Corporation, Ashton-under-Lyne, Burnley, Blackburn, Bury Corporation, Bacup Corporation, Bristol (2), Barrow-in-Furness, Birkenhead, Bury, Barnsley (2), Birmingham, Bootle-cum-Linacre, Bognor, Bournemouth (2), Brighton and Hove, Bedford, Bolton, Crompton, Crystal Palace and District, Cheltenham (2), Coatbridge, Cardiff (3), Carlisle, Croydon (2), Cork, City of London (2), Chester, Chadderton, Cambridge, Coventry, Dover, Darlington (2), Dewsbury, Dundee (3), Edinburgh, Eastbourne, Edinburgh and Leith, Ealing, Fleetwood, Folkestone, Fulham and Hammersmith, Great Yarmouth, Glasgow (4), Hammersmith and Fulham, Harrogate, Hull (2), Hanley, Hawick, Hove, Hastings and St. Leonard's-on-Sea, Ipswich, Kingston-upon-Thames and Surbiton, Kelvinside, Kensington and Knightsbridge Electric Lighting Company, London Electric Supply Corporation (City Order), London Electric Supply Corporation, Londonderry, Lambeth, Leeds (3), Lancaster, Leicester, Liverpool, Malvern and Leigh, Manchester, Salford and District, Margate and Westgate-on-Sea, Morecambe, Metropolitan Electric Supply Company, Limited, Manchester (3), Malvern Link, Malvern, Northampton, Nottingham (2), Newport (Mon.) (2), Newcastle-upon-Tyne, North-West London, North London (2), Norwich, Oldham, Oxford (2), Preston and Fulwood, Plymouth, Devonport, East Stonehouse and Compton Gifford, Portsmouth (3), Paddington (2), Preston, Partick, Hillhead and Maryhill, Paisley Burgh, Plymouth, Richmond, Mortlake and Barnes, Reading (2), Rochdale, Ramsgate and Broadstairs, Richmond, St James's and Pall Mall, Stockport, St. Martin-in-the-Fields and Strand, St. Helen's, St. Pancras, Sunderland and Southwick, Sevenoaks, Southampton, Scarborough (3), Stafford, St. George's, Hanover Square (Belgravia and Pimlico), St. Giles and Strand, Torquay, Torquay and District, Tunstall, Tunbridge Wells, Tiverton, Windsor and Eton, Woking Electric Supply Company, Limited, Worcester (2), Wandsworth, Wigan, Walsall, Wednesbury, Wolverhampton, York (3).

Electric Lighting at Messrs. John Barker & Co's.—This well-known firm of universal providers at Kensington, who occupy a range of 28 shops, comprising 42 separate departments, have just completed the erection of a new block at the corner of Young Street, in which to concentrate their furnishing and decorating business. On Monday last the firm issued invitations to a large number of their friends and customers for an evening devoted to "Music, Decoration, Electricity." The musical programme was a good one, and the extensive showrooms afforded many a study in the art of domestic decoration. The whole of this new portion of Messrs. Barker & Co's. premises is entirely lighted by electricity, the current being obtained from the mains of the Kensington and Knightsbridge Electric Lighting Company. We understand that the whole of the installation work has been executed by Messrs. W. T. Goolden & Co., who have carried out an intricate and troublesome work in the most satisfactory manner. The principal floors are lighted by 42 "Alpha" arc lamps supplied by the Planet Engineering Company. These take 5 ampères and are run two in series from the 100 volt current. In the windows and on the upper floors a number of Sunbeam lamps are used with good effect, and about 60 incandescents are made use of in the private rooms and other places. On the occasion referred to the lighting successfully stood the test of a continuous run from 4 p.m. till 2 a.m.

Electric Lighting at Aberdeen.—Electricity has recently made considerable progress in this town. The Belmont Model Laundry has been fitted throughout with incandescent lights, this being the first laundry in Scotland to adopt this mode of lighting. The proprietors of the *Free Press* were the first to adopt the electric light, and since this installation the illuminant has grown in public favour.

The Lighting of Vienna.—The lighting of the principal streets will be an accomplished fact in two or three weeks.

The Electric Light in Brussels.—The Electricity Committee is expected to meet in Brussels during the first fortnight of this month, and will then probably come to a decision as regards the different electric lighting projects which have been submitted to it. The commission was looked upon as likely to go to Antwerp one day this week on the invitation of M. Van Rysselberghe, who has organised the electric lighting of the hydraulic establishments on the Quai Flamand, by means of incandescent lamps worked by a motor of his own invention, of which we hope soon to give further particulars.

Lighting of Paddington.—The vestry invites applications for the lighting of the Borough of Paddington in accordance with specifications to be seen at the Vestry Hall.

A Falling Off in Chili Copper.—We hear from Valparaiso that in consequence of the suspension of work in many of the copper mines there has been a considerable falling off in the production of this metal.

Manchester Lighting.—Statutory powers will early next year be asked of Parliament by the City Council for lighting by electricity a centre district of Manchester, which includes a large area about Market Street, Deansgate, King Street, and Mosley Street. Provision is to be made, also, for an early future extension of the lighting to a large area on the other side of Market Street. The present gasworkers' dispute will probably greatly urge on and possibly enlarge the present scheme of municipal electric lighting.

Re Gilbert Club.—In reply to a correspondent, application for membership should be made to the secretaries, Messrs. Thompson and Meldola, City and Guilds Technical School, Finsbury, or Mr. Conrad Cooke, 28, Victoria Street, London, S.E.

The Vagaries of Electricity in America.—Another death resulted from contact with an electric wire in New York on Saturday last. It is also said that the great fire in Boston was caused by an electric lighting wire falling on a telegraph wire.

City Commissioners of Sewers.—A meeting of the City Commissioners of Sewers was held on Tuesday at the Guildhall. The Streets Committee brought up a report relative to the tenders for electric lighting, and recommending that inasmuch as the Anglo-American Brush Electric Light Corporation was in accordance with the specification based upon the conditions agreed to by the Commissioners on February 26th last, a contract be entered into with that corporation for lighting the central district, as referred to in the Committee's printed report of July 30th last. Mr. Harris spoke in opposition to the report, but, after some discussion, the report of the Committee was agreed to.

The Institution of Electrical Engineers.—The annual general meeting of the institution will be held on Thursday, the 12th December inst., at 8 o'clock, for the reception of the annual report of the council, and for the election of council and officers for the year 1890. The following paper will be further discussed :—"Electric Engineering in America," by G. L. Addenbrooke, associate.

Electricity in Inverary Castle.—Inverary Castle is to be lighted throughout by electricity, and the work will be commenced early next year, after the Duke and Duchess of Argyll have left for the south, as they will be absent for about five months.

Breakdown of a Cable.—A telegram from Calais informs us that the Danish cable, which forms the sole submarine communication with Russia, has broken in the North Sea about 130 kilomètres from Calais. Commenting upon this breakdown, a French contemporary says :—"You have announced the breaking of the Danish submarine cable which connects France and Denmark. This is the fifth time this year that this cable has been broken. Is this accident or malevolence? Still, we should be alarmed at the frequency of these breakages, the Danish cable being the only assured communication which we should have with Russia in case of a war with Germany. It is urgent to put our communications in that direction under protection from every accident and every *coup de main*. The present cable, by the frequency of its breakages, would not offer us every security; it is too near the coasts and not deeply enough submerged. The only solution is to establish a second, which should be deep enough below the surface to escape the involuntary or premeditated dragging of anchors. The Minister of War must take this important point into consideration.

Electric Treatment of Sewage.—According to a French paper the authorities of Paris intend to enquire into the subject of the electric treatment of sewage. Mr. Webster had therefore better be prepared for another demonstration of his system.

Telephony.—The Swedish Government intends to construct a new interurban telephone line between Uddevalla and Gothenburg *viâ* Vemersberg, a distance of about 65 miles.

Another Exhibition.—An International Electro-technical Exhibition is to be held next year at Frankfort-on-the-Maine. The opening has been fixed for the 1st of July.

Electric Lighting at Paris.—The great market (Halles Centrales) was lighted on Monday by electricity.

The Daily Graphic.—It is the intention of the management of the *Graphic* to bring out a daily issue. Judging from the specimen copy, as regards printing and illustration, it should be a grand success.

Mr. Carty's Article.—The paper on telephone induction, which we publish on another page, has been kindly sent to us as an advance proof by the secretary of the Electric Club.

The School of Electrical Engineering and Submarine Telegraphy.—On Friday last a special lecture was delivered at this school to its students and friends by Mr. E. T. Carter (one of its staff), entitled "The life of the late Dr. Joule, and his work in relation to Electrical Engineering." A reference was made to the movement in Manchester for a memorial to Dr. Joule; and various experiments and specially prepared lantern photographs and diagrams illustrated the lecture.

Edinburgh Electrical Exhibition of 1890.—There is every prospect of French electrical firms being well represented at the Exhibition. It is understood that the French Government will undertake the transport of French goods to and from Edinburgh, and that something like 120 electrical exhibits may be expected from France and Belgium, some of them on a large scale, the terms granted to the exhibitors by the Exhibition authorities being exactly similar to those accorded to English exhibitors through the London Chamber of Commerce.

Price of Copper.—Messrs. Frederick Smith & Co. inform us that at the end of last month the price for high conductivity copper wire was advanced ½d. per lb., making the present basis price 0 to 20 8½d. per lb.

Galvanic Batteries.—We understand that the primary battery which is being fathered by an esteemed contemporary is the "Eclipse" in a new guise, and, indeed, we could not help thinking that the name of the inventor was familiar. Readers of the REVIEW will doubtless remember the peculiarities of this element.

Batteries v. Dynamos.—How is it that Mr. Bridgman's pet scheme for lighting the City without dynamos and steam engines has fallen through? It seems that the Perreur-Lloyd system cannot possess all the virtues with which that worthy committeeman endowed it. At all events we should be glad to know when it is likely that the technical press will be invited to view the apparatus.

Elmore Copper.—If one might presume to judge of the value of a commercial undertaking by the price at which its shares were selling on the Stock Exchange, it would appear that Mr. Elmore's process for depositing copper by electricity has commenced its career of "revolutionising the whole copper industry." From the Stock Exchange official list of quotations we notice that the £2 shares in the company were dealt in yesterday at over £4, this being a rise in value of over 100 per cent. within a fortnight. We are given to understand that this substantial rise is due entirely to the heavy buying of enthusiastic believers in Mr. Elmore's process, many of whom are well known in the electrical world. The works of the company, which have been specially built near Leeds, we are informed will be in operation one day early next week, and it is the intention of the directors to submit the first product in the way of tubes and wire to a comparative test by the Board of Trade authorities.

Underground Conductors.—We learn that the Siemens concentric cable laid down in the Strand for the London Electric Supply Corporation has broken down under a pressure of 5,000 volts, and with about half its normal current. We understand the cable was tested by the manufacturers to 10,000 volts, and for the moment we are unable to state accurately the reason of the collapse. But we shall not be surprised to hear of similar catastrophes in the near future.

Accumulator Installations.—We have received a communication on accumulator installations, but it arrived too late for insertion this week.

NEW COMPANIES REGISTERED.

T. Potter and Sons, Limited.—Capital £7,000 in £5 shares. Objects: To take over the business of T. Potter and Sons, electric light, sanitary, and general engineers, of 44, South Molton Street, 361, Oxford Street, and West End, Hampstead. Signatories (with 1 share each): Thos. Potter, sen., Ardingly, Sussex; Thomas Potter, jun., and Hy. Arthur Potter, 44, South Molton Street; John Richards, 48, Liverpool Street, Walworth; G. T. Clarke, 73A, Beak Street; C. Mills, 50, Jackson Road, Holloway; J. Newman, 2, Cedar Villas, West Hampstead. The management is vested in Mr. Henry Arthur Potter, who will be entitled to a salary of £30 per calendar month, Registered 27th November by Goren and Tapp, 27, South Molton Street.

Dalziel's Cable News Agency, Limited.—Capital £1,000 in £5 shares. Objects: To supply the daily press with news from America, Europe, Australia, Japan, and all foreign countries. Signatories: Robert Dunlap, 57, Barbican; Harold King, Exchange Buildings, Liverpool, 1 share; Davison Dalziel, 1 share; Mrs. H. H. Dalziel, 95 shares; and W. H. Lingard, 1 share, 22, Elm Tree Road, St. John's Wood; G. Dalziel, Greenhill, Hampstead; A. D. Lavendair, 67, Myddleton Square, 1 share each. The subscribers are to appoint the first directors. Registered 27th inst. by Mr. S. Bird, 41, Finsbury Pavement. Registered office, 263, Strand.

Liverpool Silver and Copper Company, Limited.—Capital £50,000, in £10 shares. Objects: To treat, by electricity and other processes, gold, silver, copper, or other ores, regulus, and metals, and to manufacture wire, sheets and other forms of copper and copper alloys. To acquire land, works, and premises at Widnes, Lancashire. Signatories (with 1 share each): *James Lewis, *A. Hornsby Lewis, *F. Farrel, Thomas Court, and J. H. Atkins, of 5, Fenwick Street, Liverpool; J. H. Kenion and Alfred Tyrer, 14, North John Street, Liverpool. The first three subscribers are the first directors; qualification, 50 shares. The company in general meeting will appoint remuneration. Registered November 28th by Burton and Co., 37, Lincoln's Inn Fields.

Birmingham Electric Supply Company, Limited.—Capital £100,000, in £5 shares. Objects: To purchase a transfer of the Birmingham Electric Lighting Order, 1889, and generally to carry on the business of an electric light and power company. Signatories (with 1 share each): G. S. Albright, Edgbaston; G. Hope Johnstone, 38, Northampton Street, Birmingham; F. W. V. Mitchell, Edgbaston; J. F. Albright, C.E., Edgbaston; Sir David Radcliffe, K.B., Thurstaston Hall, Cheshire; E. Mackintosh Sharp, Edgbaston. The signatories are to appoint the first directors; qualification, £500 in shares; remuneration £350 per annum. Registered 2nd inst., by Messrs. Waterlow Bros. and Layton, Limited, agents for Messrs. Smith, Pinsent and Co., of Birmingham, solicitors.

Foreign and Colonial Electrical Power Storage Company, Limited.—Capital £100,500, in shares of £5 each, 100 of which are founders' shares. Objects: To adopt a provisional agreement of 22nd ult. with the Electric Construction Corporation, Limited, relating to the purchase by this company of certain patents for improvements in storage batteries and other property. Signatories: *Sir Daniel Cooper, 8, De Vere Gardens; *J. Irving Courtenay, The Temple; *James Balfour, 4, Marlborough Gate, W.; *James Pender, Thornby Hall, Rugby; *F. Green, 13, Fenchurch Avenue (1 founders' share each); R. Mackenzie, Dingwall Lodge, Croydon; and T. H. Horwood, 43, Woodstock Road, Bedford Park (1 ordinary share each). The signatories denoted by an asterisk are the first directors; qualification, 100 shares or £500 stock; remuneration, £1,000 per annum, and in addition 10 per cent. of profits in excess of the amount required for the payment of 10 per cent. per annum divided, provided that £5,000 per annum be the maximum remuneration. Registered 3rd inst. by Messrs. Renshaws, 2, Suffolk Lane, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Croydon Electric Supply Company, Limited.—The statutory return of this company, made up to the 20th ult., was filed on the 28th ult. The nominal capital is £5,000 in £5 shares. Only 7 shares have been taken up, and upon these the full amount has been called and paid. Registered office, 7 and 8, Ironmonger Lane, E.C.

Schanschieff Electric Battery Syndicate, Limited.—The annual return of this company, made up to the 26th ult., was filed on the 27th ult. The nominal capital is £40,000, divided into 160 shares of £250 each. 146 shares have been taken up, 60 being considered fully paid. Upon 86 shares the full amount has been called, the calls paid amounting to £21,336 17s. 6d., and unpaid to £163 2s. 6d. Registered office, 44, Basinghall Street.

East Strand and District Electric Light and Power Company, Limited.—At an extraordinary general meeting of this company, held on 17th July, at 24, The Outer Temple, it was resolved to wind up voluntarily, and on 27th ult. a final meeting was held, when a statement was made showing the manner in which the winding up has been conducted and the property of the company disposed of.

Halifax Mutual Electric Light and Power Company, Limited.—An agreement of October 19th (filed 29th ult.) between Blakey Emmott and Company, Limited, and this company, provides for the purchase from the former of all the electric plant and appliances in connection with their installation at Halifax, at a price to be agreed upon, and, failing agreement, at a valuation to be made by Messrs. Wheatley Price, Kirk and Co., of London, the amounts to be paid three-fourths in cash and the remainder in fully paid shares.

Westinghouse Electric Company, Limited.—An agreement of July 20th (filed 20th ult.) with the American company of the same title, provides for the purchase of the goodwill, the patent rights, &c., of the American company, other than for North and South America. The purchase consideration is £488,000, payable by the issue of 30,000 fully paid ordinary, and 18,800 fully paid preference shares of £10 each in this company.

The statutory return of the company, made up to the 22nd ult., was filed on the 29th ult. The nominal capital is £600,000, divided into 30,000 preference and 30,000 ordinary shares of £10 each. 3,155 preference shares are taken up, and upon 1,735 the full amount has been called, and 10s. per share has been called upon 1,420 shares. The calls paid amount to £18,060. Registered office, 4, Victoria Mansions, S.W.

Llanelly Electric Light and Power Company, Limited.—An extraordinary meeting of this company took place on the 9th ult., at 3, Vaughan Street, Llanelly, Carmarthen, when a resolution was passed authorising the striking out of clauses 18 to 23 of the articles of association. The resolution was confirmed on the 26th ult., and was duly filed on the 29th ult.

Brazilian Submarine Telegraph Company, Limited.—The directors on December 4th declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended September 30th last, and payable on the 24th inst. The books of the company will be closed from the 16th to the 23rd inst., both days inclusive.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The estimated traffic receipts for the month of November were £3,000 as compared with £3,107 in the corresponding month of last year. The receipts for the month of August, estimated at £2,700, realised £2,815.

The Western and Brazilian Telegraph Company, Limited. The traffic receipts for the week ending November 29th, 1889, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,259.

West India and Panama Telegraph Company, Limited. The estimated traffic receipts for the half month ended the 30th November are £3,069, as compared with £2,969 in the corresponding period of 1888. The August receipts estimated at £4,562 realised £4,529.

The Great Northern Telegraph Company, Limited. The receipts in November, 1889, £23,300; January 1st to November 30th, 1889, £252,406; corresponding months 1888, £250,200; and of 1887, £242,860.

The Eastern Extension, Australasia and China Telegraph Company, Limited. The receipts for the month of November, 1889, amounted to £44,147, as against £44,264 in the corresponding month of 1888.

The Eastern Telegraph Company, Limited. The receipts for the month of November 1889, amounted to £60,578 against £59,862 for the corresponding month of last year, or an increase of £716.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of November, were £2,497, against £1,950 in the corresponding period of last year.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending November 29th, 1889, amounted to £5,931.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month of November were £6,600.

LONDON COUNTY COUNCIL AND ELECTRIC LIGHTING.

At the usual weekly meeting, on Tuesday last, Mr. F. Westacott brought up a report of the Highways Committee on the subject of electric lighting. The committee stated that the electric lighting legislation of last session imposed certain duties and obligations upon the Council, and the committee had had under consideration the manner in which these were to be discharged. One of the most important duties devolving upon the Council under these Acts was that of the appointment of competent and impartial persons for the purpose of inspecting lines and works, and of certifying meters; and the inspectors were also, when required by the Council, to test for insulation and conductivity any portion of any undertaker's main through which energy was to be supplied. The duty of testing meters would involve the establishment of a station for the purpose, with the necessary apparatus; and the committee had ascertained that the cost of the instruments and accumulators and of fixing the same, together with other necessary incidental expenses, would be about £2,000, to which must be added the cost of connecting the station with the electric companies' mains, which would probably amount to about £100. Premises suitable for the purpose of a testing station would also have to be secured, and the committee were making inquiries with a view to obtaining them. As the instruments would be of considerable value, it would be necessary that a reliable caretaker should reside on the premises; and it was desirable that the caretaker should be qualified to attend to the accumulators and otherwise assist the inspectors. The committee recommended—(a) That, subject to an estimate being submitted to the Council by the Finance Committee as required by the statute, the Highways Committee be authorised to obtain premises suitable for an electric testing station; and also to obtain and fix, at a cost of about £2,100, the necessary apparatus for the station. The committee were of opinion that at present one inspector would be sufficient to carry out the work under the Acts, and that the services of a person competent to discharge the duties could be obtained at a salary of about £200 a year. They therefore recommended:—(b) That a competent person be appointed at a salary not exceeding £200 a year, to discharge the duties of inspector under the Electric Lighting Acts; and that it be referred to the committee to select a person suitable for the appointment; (c) that a person be appointed, at a salary of £2 a week, as caretaker of the electric testing station, and to attend to the accumulators and otherwise assist the inspector; and that it be referred to the committee to select a person suitable for the appointment. The electric lighting companies were required before commencing any works which they intended to carry out in the public streets, to serve notices upon the Council with plans showing how it was proposed to carry out the work, and the Council might approve such works subject to conditions, or might disapprove the same. Several such notices have been dealt with by the Council, which had attached to its approval certain conditions as to the manner in which the work was to be done. There was at present, however, no means of ascertaining that the conditions imposed by the Council were complied with; and the committee were of opinion that a person should be employed to supervise the works of the companies with a view to insuring such compliance. The committee had ascertained that this duty could not properly be cast upon the existing staff in the engineer's department; and they recommended that a person be appointed at a salary of £3 3s. a-week to supervise the works of the electric lighting companies in the public streets, and to see that the requirements of the Council are complied with; and that it be referred to the committee to select a person suitable for the appointment.

Mr. Westacott, chairman of the committee, said they felt that the Council ought to take care that the work was carried out properly to prevent such a catastrophe as recently happened at Boston.

Mr. Hunter moved, and Mr. Burns seconded a motion to the effect that the inspector should be in the engineer's department, and this was agreed to.

Mr. Campbell pointed out that the local authority had equal power with the Council in making regulations with respect to the electric light, and he suggested that the report should be referred back for further consideration and report after communication with the local authorities in whose districts the electric lighting works were proceeding.

This suggestion was not adopted, and the report of the committee was approved.

Works of the Westminster and Kensington Companies.

The Highways Committee further reported that they had considered a notice dated 22nd November, 1889, from the Westminster Electric Supply Corporation, of its intention to lay mains and distributing boxes in Victoria Street, Great Chapel Street, Caxton Street, and Dacre Street, Westminster, as shown on plans submitted with the notice. The committee recommended, and it was agreed:—

"The the Council do approve of the works specified in the notice of the Westminster Electric Supply Corporation, dated 22nd November, 1889, on the following conditions, viz.: that where two culverts are to be used, they shall be so constructed as to occupy as little space as possible; that the York stone covering for the culverts under 20 inches in width, shall be not less than 2 inches thick, and for the wider culverts 2½ inches; that where the culverts are laid under the carriage way there shall be not less than 9 inches of Portland cement concrete between the cover stones of the culvert and the under-side of the paving."

That committee having considered a notice, dated November 18th, 1889, from the Kensington and Knightsbridge Electric Lighting Company, of its intention to extend its mains in De Vere Gardens and Canning Place, and also in Beaufort Gardens, as shown upon plans submitted by the company, recommend:—

"That the Council do signify its approval of the works referred to in the notice dated November 18th, 1889, of the Kensington and Knightsbridge Electric Lighting Company, such approval being subject to the same conditions as were imposed in respect of the company's works previously sanctioned by the Council."

The recommendation was approved.

The committee had considered a letter from the same company, dated November 18th, 1889, submitting a drawing showing a point at Rutland Gate, at which two main culverts joined at right angles, necessitating the placing close together of two straining-up boxes. The placing of one box at this point was sanctioned by the Council on October 8th, and the company now asked for sanction to the placing of the second. This was an exceptional case, and as there appeared to be no serious objection to what was proposed, the committee recommend:—

"That the Council do sanction the alteration shown upon the plan submitted with the letter from the Kensington and Knightsbridge Electric Lighting Company of November 18th, 1889, subject to the conditions that there shall be a space of at least 2 feet between the frames of the boxes."

The committee's recommendation was approved without discussion.

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

"Electrical Engineering in America." By G. L. ADDENBROOKE, Associate; read Thursday, November 28th, 1889.

The last eighteen months or two years in America have been much more characterised by commercial and industrial progress with already existing types of plant and apparatus than by a number of new inventions. Inventive ability seems to have been more concentrated on improving and elaborating already existing inventions than on the evolution of new forms and ideas.

The leading types of machines and apparatus are all well known to you, and have been so fully described and illustrated that to enter into a minute account of them now would only be to traverse old ground. I therefore propose to devote myself this evening to central station, construction, and internal work, and the application of electricity to tramway and other industrial purposes. Finally, I propose to make a few remarks on the tone, policy, and aims of American electrical engineers, and those commercially interested with them in advancing the application of electricity.

My visit to America was not quite of the ordinary character, as I came through on my way from Australia, and consequently had to traverse the whole breadth of the continent before reaching the better known towns on the Eastern Coast. I was thus able to make a general, if rapid, survey of what is going on in the far West and in towns remote from the manufacturing and engineering centres, as well as in New York and some of the larger cities.

OVERHEAD WORK.

Throughout the continent, from shore to shore, the main thing that forces itself on the observer is the prevalence of arc lighting. Hardly any what we should call moderate sized village outside the oil region appears to be without its arc lamps.

Arc lamps, when used for public lighting, are usually fixed on poles from 20 to 40 feet high, according to the caprice of the parties interested in their erection; or they are slung from the corners of intersecting streets, in which case they usually hang low down; or the tower system is adopted. When posts are used they are of rough pine, never painted, often out of the straight, and warped or bent. If the lamps are fixed, iron spikes are usually driven at intervals on each side of the pole, starting about 8 feet from the ground, and forming a sort of ladder by which to reach the lamp. During my whole journey from San Francisco to New York I can hardly recollect seeing one ship-shape, neat, and smart-looking post, whether for carrying arc lamps or for any other electrical purpose. Everything has a temporary and expedient look about it, which is very offensive to English eyes. Creosoting does not seem to be practised, and the only protection applied to the poles which I saw anywhere, consisted of boards fixed round the base and reaching about 6 feet high; but this protection was, I think, only applied to large poles carrying circuits or telephone wires.

The lamps themselves are always entirely without ornamentation, and are usually very roughly fixed on the poles. If the globes are not clear glass they are usually only lightly frosted, so that the light glares in one's eyes in all its nakedness.

When the lamps are hung over the centre of intersecting streets, four wires are brought down from the corners of the neighbouring houses, the lamp hangs from the centre, and is lowered and raised by a pulley and cord. The wires from which the lamp hangs, the cord, and the leads all festoon about in accordance with the chapter of accidents, and look, as we should think, both slipshod and untidy.

The only relief to this state of things is afforded by the towers. These towers are usually erected at the intersection of streets, with the four legs at the four angles of the pavement. They are constructed of exceedingly light ironwork. Tapering gracefully upwards to a great height, they are at any rate neat and not uninteresting-looking objects in themselves, and certainly form very definite landmarks. Three or four arc lamps hung round the top of one of these towers shed a sufficient light over a great area where the houses are not high. With this method of distribution a 20-light machine can be employed to great effect; especially as in country towns and villages, where these towers are chiefly employed, the object is rather to make darkness generally visible, if I may so express it, than to provide bright illumination in well-defined places.

By using the tower method one's eyes are not dazzled by the brightness of the light, which is so much the case with lamps at a low level.

In my own case I used sometimes at night to get quite an irritated feeling when walking about, if at all tired, from the incessant glaring in one's eyes of naked arc lamps, and the impossibility of finding rest anywhere. I mentioned this effect to two or three Americans, but they did not seem to notice it.

Important, however, as the public lighting is in the large towns it occupies a comparatively inconspicuous place in comparison with the numbers of lights used for illuminating stores, saloons, hotels, restaurants, and all sorts of public buildings. Arc lamps are so lavishly used in these places, both inside and out, that the principal streets are often literally a blaze of light. There were, as far as I could ascertain, about 2,000 arc lamps in nightly use in San Francisco, 3,000 in Chicago, and I understood that 3,500 were shut down in New York while I was there, owing to the accidents which had taken place, and of which so many accounts have been published.

The majority of the arc lamps used outside are fixed by means of light iron rods projecting from the buildings, though some, of course, are hung.

The circuits feeding lamps hung either inside or outside of a building, either run direct from the nearest poles on each side of it, thus making an angle over and across the pavement which is very unsightly, or a sort of barrel-shaped glass insulator is used. This insulator has a hole through the centre and a groove round the middle of the outside. The wire coming in one direction is passed through the centre of the insulator, turned back on itself, and made off; the wire in the other direction is passed round the outside, and also made off on itself; the two ends of the loop are then carried to the lamp, through which the circuit is completed. Nearly all the wire I saw was insulated with "underwriters' insulation." Where lamps are used internally, this is often carried through wooden window frames and such other like places without any further protection or care. Once inside, the wire is carried along ceilings and walls quite exposed, but separated about 3 inches by small wooden cleats. Sometimes, instead of cleats, small white porcelain insulators are used.

As far as I could learn, it is the invariable custom for all companies to run, fix up, and entirely look after the lamps they operate. The customer simply pays a rent for the use of the lighted lamp of so much a week, month, or year, as the case may be, and has no further trouble of any sort. The rates differ according to the time the lamps are to be in use each night. To see that the lamps burn properly, linemen promenade the streets all night, and are supposed to see every lamp on their circuits at certain intervals.

The circuits themselves are almost invariably carried on poles erected along the edge of the kerbstones. A fair estimate of the average height of these posts is, I think, about 30 feet; of course some are much more, and many less. Long wooden cross arms are fixed near the top of the poles, carrying from two to six, and even eight insulators on each arm. These arms are not so strong as we should make them for the purpose. Owing to the length of the arms, and to their not being very securely fixed to the poles, the weight of the circuits often pulls them out of the horizontal. To see a warped and bent pole, set crookedly in the ground, and with the arms at various angles with each other, and the wires on it all hanging in different curves, seems about as dismal and woebegone a piece of engineering as can well be imagined.

I must make some exception, however, in the case of the Thomson-Houston Company in New York, who, at any rate, had got light iron stays attached to the poles and arms, at an angle so as to give more support to the arms, and keep them in their places.

The insulators are supported on the arms by wooden pegs, which have a screw-thread cut on the part that projects. On this one of the ordinary green glass insulators is screwed. Green glass insulators are used for every purpose in America, whether for electric light, telegraphs, or telephones. They are very cheap, and answer the purpose well. Still, the effect of green glass insulators on arms painted a dull red, fixed on bare poles from which the bark has just been stripped, is not æsthetic.

The majority of the poles for circuits have no steps provided for ascending them. On the frequent occasions when it is necessary to go up to the top to make alterations or add new circuits, the linemen use climbing irons. The tearing of the wood by the spikes of these climbing irons gives the poles a jagged and frayed-out appearance from top to bottom. One could fancy they lead to the habitation of some immense squirrel.

The Americans nearly always use solid wire for running their circuits, covered, as I have mentioned already, with underwriters' insulation. Little trouble is taken to keep the various circuits on one pole in regulation with each other, so long as they do not touch. Indeed, the whole construction of the poles and arms is so flimsy, that no great strain could be put on the wires. The poles themselves are fixed at short intervals, often not more than 30 yards apart, and seldom above 60.

The circuits are rather hung up on the poles than run, in the sense an English lineman attaches to the word. Separate suspenders I never saw used, except for telephone cables. For alternating incandescent circuits of 1,000 volts several separate cables of small size are also used, instead of running a large one with suspenders, as has been the custom here.

What I have just said about short spans for electric light work also applies to telephone and telegraphic work; the spans used in this work are generally also short. In the latter case, since the wires are light, they are run pretty taut without putting much strain on the arms, so that there is not much sag. Wires run in this way are, of course, not so liable to sway about as long spans are in high winds, and make intermittent contact or get overlapped. Further, the wires, being run along the streets, are protected from high winds in a great measure, and are not particularly exposed to them, as our over-house work is. This method of erection, therefore, rough as it is, and notwithstanding the enormous number of wires which are often suspended from one pole, gives an immunity from contacts and accidents that an English engineer at first can hardly understand or appreciate.

For leading in wires into houses, or for putting on extra wires on a pole—in fact, for general purposes of the sort—a block of wood is used, the lower end of which is cut off at an acute angle, the upper being cut away and turned down, and a screw-thread cut on it to carry an insulator. When the face of the angle is fixed against the side of a house or a pole, and a spike or screw put through it, the insulator projects somewhat, and forms a support for taking off the wire. The whole thing is of the cheapest description, but, nevertheless, seems to answer its purpose.

Wires are led in from the outside with much less care than is generally used in England; and this applies also to telephone and telegraph work. It often puzzled me how they worked at all after they had been put up a few months. But the fact that the climate is much drier, and fine rain not so frequent as here, has no doubt a great deal to do with it. In the case of arc light circuits entering and coming out of houses, and worked in series—as they always are—it is, of course, a material point that although the difference of potential between the circuit and the earth may be 3,000 volts, yet the difference between the outgoing and incoming wire is only some 50 volts; so that the tendency of the current to break across the leads is really small. Again, the chance of the current going to earth on dry ceilings and walls is, when one comes to look into it, not great. Thus, notwithstanding the rough character of most American work, and the poor insulation of the wires, in this class of work there is a greater freedom from faults and a higher margin of safety than one would at first imagine. The only place where the margin of safety is really low is where the wires enter buildings.

I have now, I think, gone over all the main points in arc lighting construction work. Construction work for alternating currents is generally carried out on much the same lines as for arc lighting; the only difference is that in the latter case converters are stuck against the outside of buildings instead of arc lamps, which, of course, are in parallel instead of in series. A rough hole is knocked through the brickwork just under the place where the converter is fixed, for the secondary leads, which are slipped through a couple of rubber tubes and carried inside. But little attempt is usually made to execute this part of the work in what we should call a neat or workmanlike manner.

Let us now make a *resumé* of this branch of the subject.

There are in America now, I believe, more than a quarter of a million arc lamps in constant use. In the large towns these arc lamps are fed by machines equal to keeping going 50 or 60 lamps each.

Outside a central station, supposing it to be for 1,000 lights, we shall find tall and untidy-looking poles 30 or 40 feet high. At the top these poles will have four or five cross arms, each carrying six or eight insulators. These poles will be continued along the neighbouring streets at intervals of 30 to 60 yards, according to circumstances. Every here and there a circuit will leave the rest for the side of a neighbourihg house, supply one or more lamps, being run in the latter case along the face of the houses, and then return again at the next pole. Or a circuit may jump across the street, supply a lamp or two, and then return again to the nearest pole on the side it first started from.

Here and there one or two circuits will leave the main line of poles altogether, and turn up a side street; in this case the poles in the side streets are generally smaller. It is surprising the length some of the arc circuits extend in this way—not unfrequently over a dozen miles.

As all the machines in a station are usually of the same size, and are run at the same speed, when the circuit is long the number of lamps fed off a nominal 60-light machine may perhaps have to be reduced to 45 to allow for the resistance of the leads. As you are aware, some of these arc machines are now used on power circuits in the daytime, which forms a very welcome source of extra revenue.

I trust I have not wearied you by a too minute description of this, a not very interesting part of electrical engineering in America; but I was anxious to convey as clearly as I could on what a remarkably simple and crude basis almost the whole fabric of American electrical engineering in this particular at present rests. For I think I am not overstating facts in saying that at least nine-tenths of all the electrical work in America—putting aside isolated plants—is carried out, as far as the construction work is concerned, in the manner I have described. In all this portion of the work I saw next to nothing which showed particular ingenuity, skill, or brilliancy of idea. Simple and crude means were everywhere used to effect in a rough and crude manner the end desired. In the means employed there is little to excite either admiration or interest. The interest lies in the fact that in such a simple and elementary manner so much has been done.

UNDERGROUND WORK.

Turning now from this branch of the subject to underground work, I must confess that I had a good deal of difficulty in getting really accurate and reliable information on this subject—at any rate, of a comparative character. The Edison Company have, of course, buried their wires all along, and their three conductors enclosed in an iron tube, run solid with insulating material inside, are well known. As far as I could ascertain, the various systems of conduits have not proved very successful so far, and, since the proof of the pudding is in the eating, the fact that the Subway Company in New York are, I believe, laying down iron pipes entirely—at least, they were in every place I saw work going on—points to this conclusion.

The system of construction for underground work at present being carried out in New York is as follows:—

Manholes at convenient distances are made in the roadway—not, as a rule, in the pavement, but just on the rise of the road, and clear of the gutter. These manholes are circular, and are covered by a heavy iron lid. Below the manhole is a bell-shaped pit 8 or 9 feet deep, and bricked round, and of sufficient size at the bottom for a couple of men to stand fairly comfortably to work. Iron pipes, such as are used for water or gas, are laid in the ground from one manhole to the next. I understand that each electric company will, as a rule, have a separate pipe, so that if there are several companies running along the street, they will each require a separate line of piping opening into the manhole. There will, therefore, often be several pipes entering at each side of the manhole. These pipes enter the manhole at such a height as, roughly, to come between the hips and breast of a man standing on the bottom—at a height, in fact, to bring them in a fairly convenient position for working. The cables are drawn through the iron pipes in the ordinary way. Branches are taken from the manholes under the roadway and pavement to any house between the manholes requiring current.

As regards the class of cable which is being largely laid down in these conduits, the conductor consists of seven strands of No. 16 copper. These are insulated by a layer of a hard but somewhat flexible material, containing, I believe, some rubber in conjunction with other materials, but the complete material is cheaper than rubber used alone. The thickness of this material surrounding the conductors is one-twelfth of an inch. It somewhat resembles ebonite, and is of a consistency to stand rough usage and hard wear. It will be interesting to see how it lasts in practice. I must say it seems to me a very suitable material for the purpose for which it is intended; and as far as insulating qualities go, I was able to see the record of tests of a good deal that has been laid, and they were excellent, going up to several thousands of megohms per mile. The insulating material is covered with a lead pipe about one-sixteenth of an inch thick, and containing, I believe, a percentage of tin. These lead-covered cables are usually jointed at each manhole, and a little slack left on them there. The jointing is done by a special system, and when it is complete electrically the two lead tubes are drawn together over a small bit of brass tube, which protects the point of junction; they are then "wiped" together with a hot iron like an ordinary plumber's joint. No doubt this work is heavy and expensive, but it looks as if it should last when once put down.

INTERNAL WORK.

Coming now for a moment to the internal work in buildings, most of what I saw had a rough, temporary look about it, evidently being put up as cheaply as possible. I do not say that no good, solid work is done, but the proportion of it to the remainder is, I fancy, a good deal smaller than in this country.

Gas fittings are freely utilised, and I think I am correct in stating that in the arrangement of lights the gas-fitting way of managing things is adhered to much more closely than in this country, where we have rather tried to avoid imitating the ordinary ways of arranging gas lights.

Turning aside for a moment, it appears to me that one of the great wants all over the world now is, if I may so term it, a "science of illumination." Up to and as far as *providing* light, we are exceedingly scientific. But in *utilising* it when we have got it we proceed in an elementary and haphazard manner.

Mr. Preece has, I know, from the first paid a great deal of attention to this point, and appreciated its value. It seems to me that it would really be of great practical benefit if a committee of this Institution, or some other responsible body, would accumulate some accurate and authoritative data on the subject. When once started properly, these data would increase of themselves, and would soon form a guide which would be exceedingly useful in drawing up specifications and arranging to the best advantage the lighting of either open spaces, public buildings, or private houses.

We all have our own indefinite notions on the subject as the result of experience, but if they could only be put into definite shape—and I think the subject does admit of being put into definite shape—it would, I feel sure, be a great advantage.

Of course there are innumerable patterns of switches and cut-outs and fittings in America, as here, but none came to my notice showing any very brilliant conception in design. Lamp sockets and fittings are generally somewhat larger and clumsier than with us.

The chief difference I noticed was that a switch is almost invariably included in each lamp socket. Americans, as a rule, do not go to the same amount of trouble and expense that is general here to fix switches in handy places near doors. If you want the light on or off, you turn it on or off at the burner as you would do gas.

(*To be continued.*)

A NEW VIEW OF TELEPHONE INDUCTION.*

By JOHN J. CARTY.

Mr. President and Gentlemen of the Electric Club:

One of the most peculiar developments connected with the introduction of the telephone was the presence of remarkable sounds which were heard when the telephone line was of any considerable length. Sometimes it sounded as though myriads of birds flew twittering by; again, sounds like the rustling of leaves and the croaking of frogs could plainly be heard; at other times, the noise resembled the hissing of steam and the boiling of water. Even a display of Aurora Borealis causes powerful currents in the telephone.

At one time, I think it was in 1882, during the prevalence of sun spots and after the appearance of a comet, the auroral current became so strong on a line from Boston to Brockton as to operate a miniature arc light which I improvised out of a pair of lead pencil carbons and connected into the line.

Some of these disturbances have been more or less satisfactorily accounted for by assuming differences of potential at the two ends of the line; by the sudden heating or cooling of the line; and by the passage of electrified bodies of air or clouds.

Another very curious effect was observed when the first two telephone wires were run parallel to each other on the same cross-arm for the distance of even a few miles; it was found that although the insulation of the lines was high, a conversation carried on over one wire could plainly be heard on its neighbour. This overhearing is commonly called "cross-talk." As the number of telephone wires increased and their bunching together in cables became necessary, it was found that in addition to the cross-talk, there was another element of trouble added, which was due to the electro-static effect of the cable, and caused the voice to be transmitted in an indistinct and muffled manner. This evil exists to such an extent that where cables are used the speaking limit is soon reached.

While a study of the strange noises heard in the telephone might be of interest, I shall in this paper limit myself to the consideration of cross-talk and to the action which takes place when wires are bunched in cables. In the simple case of inductive cross-talk first cited, in which two telephone wires are strung parallel on the same cross-arm, the presence of cross-talk is said to be due to dynamic or current induction; that is, if a current commences to flow in one of the wires from north to south, it will at that instant cause an induced current to flow in the other wire in the opposite direction, from south to north. As the telephone current is constantly changing its direction and strength, this explanation seems to apply and is the one given in the text books.

This is the kind of induction referred to in the law of Lenz, and applies to induction coils and to parallel wires when the current is of sufficient strength. I shall speak of this hereafter as electro-magnetic induction. To-night I shall describe some experiments which seem to prove that the induction between telephone wires is due to electro-static rather than to electro-magnetic action.

†I will first show a case of electro-static induction between telephone wires in which there is a neutral point at the centre of the secondary wire, at which point there is no induction, while at the ends marked inductive effects are noticeable.

In fig. 1, E, F and C, D are two well insulated parallel telephone wires, each 200 feet long, and placed ¼th of an inch apart. E, F is open at one end and connected to ground at the other through a Blake transmitter, L, in the ordinary manner. In front of the Blake transmitter I place a vibrating tuning fork, which acts on the transmitter in the same manner as the voice, and which produces impulses on the line, E, F, of the same strength as voice currents. At the centre of the line, C, D, we have the telephone, Y, and at the extreme ends the telephones X and Z. With the tuning fork at L in operation, tones are heard at X and Z, but the middle telephone, Y, is silent. A study of the changes of potential produced in the wire, E, F, by the transmitter will give us an explanation of this phenomenon. As is well known, the telephone current is an alternating one, and the potential of the line, E, F, varies constantly and is changed from positive to negative many times per second. The wire, E, F, being open at E would be at the same potential throughout. It is assumed that at a given instant the height of potential at F would be represented by the dotted line, F, H; then the potential at E would be represented by the dotted line, E, G, and the total charge on E, F would be represented by the rectangle, E, G, H, F. We will assume that this charge is of the minus sign. The existence of this charge on E, F pre-supposes the presence of a charge of opposite sign on C, D, which would be represented by the rectangle, A, C, D, B.

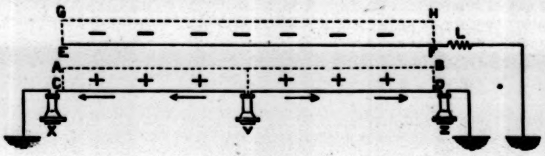

FIG. 1.

Now, suppose the potential on E, F becomes zero, owing to the operation of the transmitter, then the whole charge on E, F gets to earth at the grounded end of E, F, but the charge on C, D has two paths to earth, one at C and the other at D. This results in two currents, as shown by the arrows, one flowing to earth through the telephone, X, and producing sound at X, and the other flowing to earth through the telephone, Z, and producing sound at Z. No current flows through the telephone, Y, and consequently no sound is produced therein. Again, changing the potential of E, F causes a corresponding set of currents, but in opposite directions to those first described, meeting in the centre and producing no sound in the centre telephone, but causing the end telephones to give out sounds the same as in the first instance. Inasmuch as the line, E, F, is opened at one end and therefore has almost an infinite resistance, it is clear that this phenomenon is purely an electro-static one.

In this and the succeeding experiments I have not attempted to give the exact shape of the induced charge, as it would unnecessarily complicate the subject and would not in any way affect the result. As a matter of fact, the dotted line, A, B, should slope off from the centre toward the ends.

With the line, E, F, grounded through an ordinary subscriber's line and instrument, the effect is the same as when the line is open, and the neutral point is still found. This is because the telephone current, even when flowing in a close circuit, is so weak that it is not capable of producing a magnetic field of sufficient strength to affect the neighbouring wire, or the magnetic effect is so small that it is obliterated by the movement of the static charge. For convenience in some of the succeeding experiments, the disturbing wire will be shown open at one end.

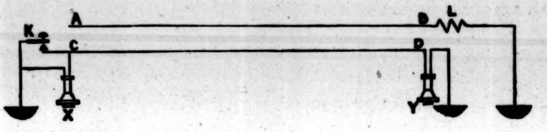

FIG. 2.

If there is no current flowing at the neutral point, opening the wire at that point should have no effect on the telephones located at the ends. In fig. 3, A, B, is the disturbing wire with the transmitter, L, arranged as before; K is a key located at the neutral point of C, D. With the transmitter, L, in operation, no change is produced in the tones heard at the telephones, X and Y, by opening and closing the key, K. If this induction were electro-magnetic, opening the line, C, D, would prevent current from flowing in any part of the circuit. In fig. 2 we have another proof of the electro-static nature of telephone induction. A, B, is the usual disturbing wire with the transmitter, L. C, D, is the secondary wire with the telephones, X and Y, located at the ends, as in the previous experiment. By means of the key, K, the telephone, X, may be cut in

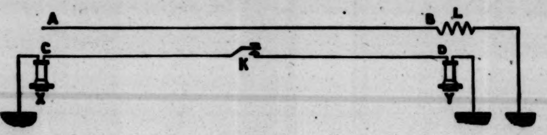

FIG. 3.

and out of the circuit. With the key open, the usual tones are heard at X and Y. Now, if the induced current flowing in the circuit, C, D, is due to electro-magnetic induction, upon short-circuiting the telephone, X, and thereby reducing the resistance of the circuit, C, D, the strength of the induced current should be increased and the tone at the telephone, Y, should be correspondingly louder. But this is not the case, as on closing the key the sound at Y, instead of being increased, entirely disappears. This is because the charge on the wire, C, D, finds an easy path to earth through the key, and such a small portion of the charge goes to earth through the telephone, Y, that no audible effect is produced therein.

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* Paper read before the Electric Club, November 21st, 1889.

† In explaining an experiment of Mr. Culley before the Society of Telegraph Engineers in 1875, Mr. Preece pointed out that in a certain telegraph line subjected to induction from a neighbouring telegraph line, there was a neutral point. I can find, however, no reference to this in Mr. Preece's book on "The Telephone," and its practical application to telephone induction seems to have been lost sight of.

Fig. 4 shows the disturbing wire, A, B, arranged as before, but the secondary wire instead of being put to earth at both ends has its circuit completed by a second wire placed outside of the field of A, B. With this arrangement, neutral points are found at T and T^1, while the usual disturbances are heard at telephones R and R^1, located at the ends. In this case a movement of the static charge takes place in the metallic circuit, causing at one moment a set of currents starting from T^1 in both directions through the end telephones and meeting at T, and at the next instant the reverse takes place.

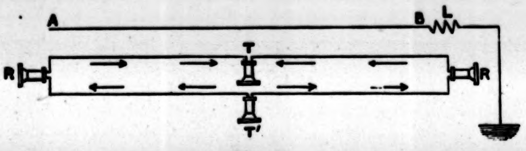


FIG. 4.

I will now show some of the effects of electro-magnetic induction, at the same time suppressing electro-static induction.

In fig. 5, A, B is the disturbing wire as before, but grounded through a short thick wire at A. Instead of placing the tuning fork in front of the transmitter, L, and acting on it through the air, producing delicate currents like voice currents, an automatic circuit breaker and five cells of Leclanche battery were connected in the primary circuit of the transmitter, thus producing in the line, A, B, alternating currents of great strength. The secondary wire containing the telephones, X, Y and Z, is of the same length and at the same distance from the disturbing wire, as in the previous experiments. With the circuit breaker at L in operation, loud musical tones are heard at X, Y and Z, and the tone is the same in all three telephones, the neutral point in this case having disappeared. This is a true case of electro-magnetic induction, because short circuiting the telephone, Y, increases the sound in the remaining telephones and leaving the short circuit on Y, and short circuiting the telephone, X, still further increases the sound at Z. This latter experiment furnishes a most striking contrast to the result obtained in fig. 2, where by short circuiting the telephone, X, the sound was completely removed from the telephone at the other end of the line.

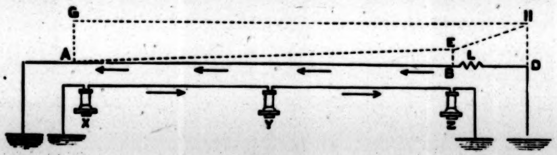


FIG. 5.

Another proof that this is electro-magnetic induction, is found in the fact that if the line be opened at Y, the sound disappears from all the telephones. If the line, A, B, were opened at A, the potential along the line would be constant, and the charge which A, B would take would be represented by the rectangle, A, G, H, D, but when the line is grounded at A through a low resistance, there is, of course, a fall of potential along A, B; the principal drop, however, occurring in the secondary coil of the transmitter, L, the line, B, E, representing the height of potential at the terminal of the coil, and the electrostatic effect which the line, A, B, would have, is represented by the triangle, A, E, B. This triangle, although exaggerated in the diagram, is still much smaller than the rectangle, A, G, H, D, and explains the absence of the electrostatic induction between the wires, while the powerful current generated in L, and the comparatively low resistance through which it has to flow, accounts fully for the electro-magnetic effects observed.

I have made a large number of laboratory experiments and observations on actual telephone lines, all of which point strongly to the conclusion that electro-magnetic induction does not exist in telephone lines outside of the telephone and transmitter. This view of the subject applied to the theory of transpositions of metallic circuits and to the action of wires in cables gives the only satisfactory explanation of observed phenomena.

Now we come to the important question: Can this electrostatic induction be prevented? In answer to this, it can be said that the cross-talk due to electrostatic induction can be eliminated by properly constructed metallic circuits. But there still remains the muffling effect referred to in the first part of this paper. This is sometimes called "electrostatic retardation," and comes in wherever two telephone conductors are run close to each other for any great distance. Where telephone wires are strung upon poles and are at a distance of a foot or more from each other, this action is very small, but where they are bunched together in cables, a hundred or more within a 2-inch pipe, it is very great. It is a curious fact, however, that the amount of this trouble, other things being equal, depends on the character of the insulating medium or dielectric, as it is called, but is independent of its specific insulation resistance, the induction being less when air is used as an insulator than with any other substance among the materials adopted in practice. Dry cotton, paper and silk rank next to air in this respect, but when gutta-percha or any of the rubber compounds are used, the induction is much greater than with the other materials mentioned. This peculiar property of an insulator, *i.e.*, the facility with which it allows induction to take place through it, is called its "specific inductive capacity." In the present state of the art, then, the only way to overcome electrostatic retardation, after having an insulator or dielectric of the lowest specific inductive capacity, is to increase the distance between telephone conductors. It is evident that in underground systems this distance can never be great. In all of our large city underground systems the space which is allowed for each wire is ·125 of an inch.

This putting wires underground in cities is the only bar to a universal system of telephony, and if direct air lines were built, New York and Chicago would be placed within speaking distance of each other at once.

To place telephone wires underground and maintain the same efficiency as in overhead lines, would require an insulation on each wire of over 2 feet in thickness, and instead of getting 50 pairs of wires into a 3-inch pipe, as at present, a tunnel occupying half the street would be required for one cable alone. When we consider that a telephone office of even moderate size would require about a hundred such gigantic cables, it is seen how almost hopeless the case becomes.

Most engineers think that this difficulty is inherent in the problem, and that the electro-static action can only be overcome by separating the wires as already stated.

In view of the recent researches tending to give us a deeper knowledge of the nature of electricity which have been conducted by Hertz and others, I think there is reason to hope that some other way out of the difficulty may be found. You are all, no doubt, familiar with those celebrated experiments wherein electrical undulations of many million times per second were produced, and although they were transmitted along a conductor with the velocity of light, yet they followed each other with such rapidity that nodal points were produced, the location of which determined the length of the waves. These waves have been produced in various ways, and by means of large prisms of pitch and by metallic mirrors they have been refracted, focussed and reflected. In fact, they have been found to obey much the same laws as light waves.

I think it must follow from these experiments, that our disturbing wire, A, B, is throwing off, laterally, waves of great length, and that these waves impinging upon the adjacent wire, C, D, produce the various inductive effects observed.

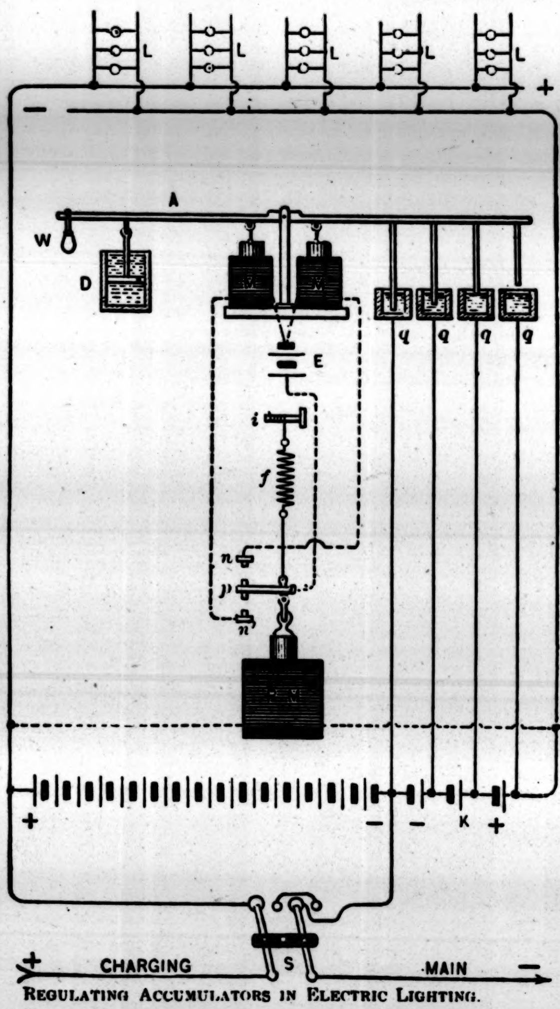
Now, if by some means, these waves could be deflected from their course and prevented from falling on the wire, C, D, it follows that there would be no disturbance whatever produced therein. We know that if these waves were of the same length as light waves, this action could be prevented by the interposition of a properly-shaped lens of glass, or by a mirror; or if they were of the length used in Hertz's experiments, a lens of pitch or a metallic mirror would have the same result. Now, although the telephone waves are of great length, it seems possible that by interposing a properly-shaped dielectric or combination of dielectrics, that an interference or refraction might be produced which would have the desired result.

This electro-static problem is one of the most important, and until within a year or two, the least studied, and is at present the least understood of all the various difficulties with which we are confronted, and the reward which awaits its proper solution is greater than that which fell to the lot of the inventor of the telephone itself.

REGULATING ACCUMULATORS IN ELECTRIC LIGHTING.

IN the discussion which followed the reading of Mr. Geo. B. Prescott, jr.'s, paper on the above subject before the American Institute of Electrical Engineers, the author referred to another method not included in the paper, which we give below.

In the diagram the lamp circuits, L, are shown at the top, leading from the mains (+) and (−). Connected across the lamp mains, preferably at a point of average potential, is the solenoid magnet, P, M, which is wound with fine wire. The position of the plunger or armature of this magnet is so adjusted by means of the retractile spring, *f*, that when the pressure is normal the contact lever, *p*, carried by the plunger, is midway between the local contact points, n, n^1. Probably most of my hearers are familiar with the Kohlrausch voltmeter, which is constructed on this principle of the solenoid magnet, and are aware that while it is not an entirely reliable instrument on account of variable friction and hysteresis, it still has a wide range and is very sensitive when the plunger occupies a given position. Now this magnet, P, M, depends on this fact, and only needs to be accurate for one position of its core. If, for example, the magnet is wound for 100 volts, then, when it is connected with two points in the lamp circuit, having a difference of potential of 100 volts, the core will occupy a certain position. If the pressure exceeds 100 volts, the core will be drawn into the magnet. If the pressure falls below 100 volts, the core will be withdrawn by the retractile spring. This core of the pressure magnet is suspended from the adjustable shaft, *i*, on the spring, *f*, and carries the local contact arm, *p*, on its upper end. When the core is drawn into the magnet this is brought into contact with the screw, n^1, and when it is drawn out by the spring, contact is made with the screw, n. So long as the pressure remains normal, the contact arm remains midway between the screws, n, n^1, for which position the primary adjustment must be made. If now the pressure becomes either excessive or falls below normal, the circuit of the local battery, E, will be closed respectively through one or the other of the local solenoid magnets, M, M′. The cores of these local magnets are attached to a balanced lever, A, at equal distances from and on opposite sides of its point of suspension, and the whole constitutes a simple modification of the regulator shown in figs. 14 and 15 of the paper. The necessary weight of the lever on the side carrying the contact rods which dip into the mercury cups, q, q, &c., is compensated for by extending the lever for an equal distance on the opposite side of its fulcrum, and by adding a suitable counter weight, W.



REGULATING ACCUMULATORS IN ELECTRIC LIGHTING.

The operation of this apparatus requires that the lever should remain quiescent in whatever position it may be drawn by the action of either magnet M or magnet M′; and that, moreover, any movement of the lever at all, tending to make or break contact with the mercury cups, should be very gradual. Both of these results are accomplished by introducing a slight friction at the point of suspension of the lever and by adding a carefully adjusted dash-pot, D, in the manner shown in the sketch. Thus, while the slight friction alluded to causes the lever to remain at whatever angle it may be placed, the dash-pot prevents the lever from moving except very slowly to whatever position the action of either magnet may tend to set it.

The function for which this regulator is employed is precisely the same as that performed by the somewhat similar regulator shown in figs. 14 and 15, viz., to insert in, and withdraw from, the main lamp circuit more or less counter-electromotive force cells, K, according as the pressure at the lamp terminals exceeds or falls short of the normal. The regulator acts in the following manner: Assuming the potential to be normal, the local contact lever, p, will stand midway between the contact points, n, n^1, and the regulator lever, A, will be horizontal, as shown in the diagram. Now if the potential at the lamps increases, the core of the pressure magnet, P, M, will be drawn down until it closes the local circuit through n^1 and magnet M, and this latter magnet will slowly tilt the lever, p, toward its side, and thus cause first one and then another of the counter-electromotive force cells to be inserted in the lamp main, thereby reducing its potential. When a sufficient number of cells have been inserted in the lamp circuit in this manner, to reduce the pressure again to normal, the core of the pressure magnet again resumes its normal position, breaking the local contact at n^1, while the lever, p, continues to remain in its new position. If, from any cause, the pressure at the lamps now falls below normal, the attractive power of the solenoid, P, M, will become correspondingly reduced, and the retractile spring, f, will draw up the core until the contact lever, p, closes, through the point, n, the local battery circuit through the magnet, M^1. This causes the lever to be gradually tilted in the opposite direction from before, and therefore to cut out of circuit one or more counter-electromotive force cells until the normal pressure at the lamps is again restored.

It will be seen that this regulator thus automatically maintains a constant pressure at the lamp terminals, irrespective of the fact whether variations of this pressure are caused by the charging current, or by the resistance of the leads when the lamp load is altered.

NEW PATENTS—1889.

18365. "Improvements in and connected with plates for primary and secondary batteries." J. B. ENTZ and W. A. PHILLIPS. Dated November 18. (*Complete*)

18377. "Improvements in signal and telegraph apparatus.' R. ARMSTRONG. Dated November 18.

18414. "Improvements in electrical tramways or railways." J. HOPKINSON. Dated November 18.

18439. "Recording the strength of an electric current." W. H. DINES. Dated November 19.

18481. "Improvements in secondary or storage batteries." C. PAYEN. Dated November 19. (*Complete.*)

18571. "Improvements in the construction of conduits for carrying electric light and other electric lines or cables." J. C. RICHARDSON and H. MCKENNA. Dated November 20.

18578. "Improved apparatus for registering the consumption of the electric current." S. W. MAQUAY. Dated November 20.

18651. "A system of conducting and distributing at a distance electric currents of large quantity from a low pressure continuous current generator." J. A. MCMULLEN. Dated November 21.

18654. "An automatic electrical device for signalling changes of temperature." R. H. GOULD and E. UBRIG. Dated November 21. (*Complete.*)

18700. "Improvements in connection with electric battery cells." T. W. WATSON and A. H. WATSON. Dated November 22.

18712. "An improved form of connection for electric lamps for stage battens, footlights, &c." J. B. VERITY and J. O. GIRDLESTONE. Dated November 22.

18755. "Improvements in the manufacture of plates for use in secondary batteries or electrical accumulators." A. RECKENZAUN. Dated November 22.

18779. "Improvements in material for making wire fencing, applicable also to the manufacture of telegraphic wire." J. BERESFORD. Dated November 23.

18817. "Improvements in electric mechanism for operating telephone call bells and annunciators." H. BIRKBECK. (Communicated by F. W. A. Schneider and W. C. Zeidler, Canada.) Dated November 23. (*Complete.*)

18821. "Improvements in electric baths or apparatus for applying electricity for medical or other similar purposes." G. GAERTNER. Dated November 23.

18847. "Improvements in gas or vapour engines and in electric exploding devices or apparatus for such engines." M. M. BARRETT and J. F. DALY. Dated November 23.

CORRESPONDENCE.

Dynamometers.

I have read in your issue of the 22nd inst., in the report of the proceedings of the Institution of Electrical Engineers, a description of a dynamometer pulley. Some years back I designed a dynamometer pulley with liquid (water or glycerine) to transmit the power from pulley to shaft, which fulfils the conditions required, as stated on page 591 of REVIEW. This pulley being without levers or pistons, and cheaply constructed, and not patented, may be of interest to some of the readers of the REVIEW. Particulars are: The rim was mounted loose on the sleeve made to go on shaft to be driven, and drove this sleeve and the shaft by means of a series of lugs cast on the inside of rim of pulley; these lugs come in contact with two or more collapsable chambers (the ordinary vacuum chambers of aneroid barometers), placed so that their surfaces were radial to the shaft and supportod on arms projecting from the sleeve fixed to shaft, and are pressed between them and the lugs on pulley. Each chamber has a tube down the arm supporting it and communicating with an elastic chamber of the same kind placed over the end of shaft, and the whole fitted with liquid so that any pressure on the radial chambers is at once communicated to the central one which has a spring pressing on it, and in the centre a small cup jewel is cemented, against which a hard steel point rests and communicates the motions of the jewel to an index lever moving over the divisions of a scale, the value of the divisions on which have been determined by experiment, as also is the value of a certain deduction to be made for *each* speed to allow for the centrifugal tendency of the liquid tending to act in opposition to the pressure of the lugs on the radial chambers.

Gerald Percival.

Cork, *November 27th*, 1889.

Units of Measurement.

I enclose herewith a fragment of a paper that I wrote some years ago, and should be obliged if you will let me state in a few introductory lines my reasons for wishing to see it published, after I have for so long laid it aside.

At the time I wrote it I belonged to the small and despised sect who regard the multiplication of concrete quantities as mere nonsense, and the equations giving the dimensions of physical quantities as really analogous to formulæ for transformation of co-ordinates in analytical geometry, and I wrote my paper in support of this view, and as a sort of *reductio ad absurdum* of physical equations. I afterwards became dissatisfied with it, regarding it as somewhat too ponderous a joke, and not dreaming that it could have any serious philosophical value. I chanced lately to mention the subject of the paper to a friend, who is better acquainted than myself with the valuable work being accomplished by our physical societies, and was astonished to learn that the same subject had been treated by Mr. Blakesley in a paper published this year in the *Philosophical Magazine*. On consulting Mr. Blakesley's paper, I found that whereas he, like myself, proposed to make the electrostatic and electro-magnetic systems identical, and thereby to reduce the fundamental units to two, it had not occurred to him to reduce them to *one* by adopting the astronomical unit of mass; and this is surely so important a simplification that it will justify my offering the system founded on it to the consideration of the scientific world.

The objection which formerly appeared fatal to the adoption of such a system, viz., the enormous size of some of the units, is quite removed by Mr. Blakesley, who justly points out that for practical purposes we may divide them by some power of ten; true, the units so obtained would be no longer systematic, but at least our physical constants would be all powers of ten, easy to remember, and convenient to use.

Perhaps I may be allowed a word of adverse criticism of a paper for which in general I have so strong a feeling of admiration, and which has opened my eyes to the unsuspected value of my own efforts in the same direction. Mr. Blakesley speaks of the unit velocity which he proposes as only thirty times that now adopted. Now it would, of course, be both foolish and wicked to deny that the ohm is a velocity, but one may be permitted to question whether it is yet universally accepted as the unit of velocity. I have not yet heard that the B.A. unit of a centimetre per second (a *velo* according to some of our dynamical teachers), has been discarded; even the old-fashioned *foot a second* is occasionally used, and has lately received a name (*fas*).

I should, perhaps, apologise for sending my communication in its original state, but by so doing I shall, I hope, escape the imputation of having plagiarised from Mr. Blakesley, for no one could, after reading his paper, treat the subject of *units* otherwise than seriously; and if you, Sir, can find space for this explanatory letter, I may hope to save myself from the scorn of the gentlemen who measure self-induction with a tape, when they see how sincere is my repentance, and how anxious I am now to further methods which I once thoughtlessly despised.

W. H. Madden.

November 26th, 1889.

The Silvertown Strike.

As incorrect statements continue to appear in some of the daily newspapers with reference to the strike at this company's Silvertown Works, we shall be obliged if you will publish the following facts in your columns.

In consequence of 380 of our workpeople striking, about 900 others, whose work was dependent on steam power, were thrown out of employment. Of this number and of the original strikers many have found work elsewhere.

It has been stated that we have lately taken on a few "calendar hands" only; but the fact is, we are glad to say, that, as we have been able to provide steam power, about 350 of our old hands have within the last few days returned to their employment in our various workshops. Others have applied, and we will take them on as fast as we can arrange work for them.

The number now in our employment at Silvertown is 795. Our wages list for this week amounts to £1,350, most of which will go to alleviate the distress in the neighbourhood, distress which has been caused by the action of the strikers, and prolonged by the mis-statements and misleading promises of the agitators.

Wm. J. Tyler, *Secretary,*
India-Rubber, Gutta-Percha, and Telegraph Works Company, Limited.

Energy and Electricity.

Having had so much in hand during the last week prevented me answering the letter in which Mr. Fitzgerald has, I notice, severely attacked and criticised mine of the 15th inst. Of course, retaliation is possible, but not advisable. It would simply be a case of the biter being bitten, trying to rebite, and I have no doubt, being re-bitten, and so it would go on *ad infinitum*; but science would gain nothing by such a course. Mr. Fitzgerald has perhaps only replied as I might have expected, so in order that "the young student" shall no longer "be mystified," I will try my best (a fair amount of thought on my side *versus* much experience on the other), to answer in a friendly manner the points put forward. I would first, however, like to know why an answer to my simple question on factors and products was not forthcoming?

As far as I can make out, there is no difference between electricity and electrical energy, nor can I see that Mr. Fitzgerald himself has made that distinction, although he asks others to do so. Electricity is a common class name for a number of forms of intermolecular motion, and intermolecular motion may be considered as a form of, as well as the result of energy. The condition of the molecules of a body is, of course, a primary, though not necessarily the initial, energy. This influences, induces, or imparts active or potential* energy. If we sought for this initial energy—the source of the condition of molecules—we might have to leave physics, and branch off into metaphysics. Then would crop up the very natural question: "Where do physics end and metaphysics begin?" I regret not having the pleasure of personally knowing Mr. Fitzgerald, and am therefore ignorant as to some of his views. To those who deny the existence of metaphysics, and maintain that all that takes place in nature is due to physical effect alone, I would respectfully decline further reply, as it would carry us far beyond the legitimate scope allowed us in the columns of this invaluable Journal. To all else intermolecular motion must, to all practical intents and purposes, be considered as the primary energy; and whence *that* is derived should not at the present moment trouble us.

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* In this letter the term "potential" must be used for intermolecular motion acting on another body, "latent energy" being used for cohesion, "semi-active energy" for intermolecular energy apart from its effect, leaving "kinetic" for the body in motion.

Now this intermolecular motion, or, in other words, the semi-active energy of a body, may influence the latent (cohesion), semi-active, or even the active energy of another, making the latent semi-active; the semi-active active, and the already active more active.

Again, "quantity of electricity" is a misnomen. Literally speaking, it is the *intensity of the intermolecular motion*. The greater the motion, and the greater the mass in motion, the greater, I should say, would be the influence exerted. A high ampèrage, *i.e.*, a condition of great internal motion, would necessitate a condition of separation of the particles. This is the same as what takes place when a body is heated. In fact, if excessive motion take place, and a person touch the so-excited body, he experiences the same sensations as when a heated body is touched; it is indeed said to be hot. I have, at the expense of much time and trouble, worked out a number of tables, and from these I gather that, for a body to be a so-called good conductor, three things are essential: (α) a high boiling point (1,000° C. or more); (β) elasticity; (γ) small atomic volume. Bodies of low boiling point, brittle, lightly fluid or volatile, and of great atomic volume, are either poor, or non-conductors. The reasons are plain.

A high boiling point denotes a great affinity between the molecules—they necessarily easily influence each other.

Elasticity denotes a certain amount of freedom of motion among the particles.

Small atomic volume assists internal activity, for there must be more particles to a given space.

A body lacking one or more of these attributes must offer a certain amount of resistance. It may here be worth while noting, although there is no time to seek for a reason, that nearly all the good conductors act electropositively, while the bad ones act electronegatively. A hot wire offers more resistance than a cold one. What does this mean? Simply that the molecules of the wire less easily affect each other, being further apart. If F = resultant force exerted, m = mass, f = an accelerating force, M = momentum, and v = velocity, then $F \propto m \times f$.

$$M \propto m \times v.$$

Now, f is a species of velocity, therefore F must be a species of momentum. Now, in treating of that condition of a body which we say is giving out volts, we can call that intermolecular force which acts on other bodies, F. As I have shown above that body is energetic, or, in other words, the particles of the body are thrown with a certain momentum against those of another: therefore F, *or that force which the particles of a body exert outwardly, is analogous with active*, or, as Mr. Fitzgerald would call it, *kinetic energy*. The true meaning of voltage, then, is the momentum with which the particles of a body, in an electric condition, strike against those of another. This, for dynamical problems. In statical problems f can be eliminated, it invariably cancelling out on either side of the ratio; and as the result we obtain $F \propto m$, which we may use in dealing with inter-molecular motion, apart from its effect on other bodies.

Answering some of the queries so thoughtfully suggested; I will say, in answer to question (*a*), that I have heard of and studied mechanical dynamics; but I am not bound to accept all I read without duly analysing. It is the result of such analysis which all along I have been endeavouring to explain, and, I trust, this time satisfactorily. Question (*b*) is, I believe, already indirectly answered.

Question (*e*) takes, seemingly, for granted that work and potential energy (*i.e.*, that which does the work), are one. How that can be I know not; but the consequence is that in (*f*) there is but one solution, where I should have expected two.

The series of equations I am at present unable to criticise, not knowing what each letter denotes, and not being able to find from what text book they were obtained. They may be algebraically correct, but one thing is certain, they are very misleading. In the first place, they should not be equations, but ratios. From the context I gather that m = mass and s = space. In such a case, whatever W may be, it would have been more correct to have written $W \propto a\,m\,s$ instead of $W = a\,m\,s$; and similarly in all the other cases. Now, as I have said, I cannot yet go into the merits or demerits of these formulæ, but, as they at present stand, it is as likely as not that they lead to many a funny paradox. Suppose the money paid for a thing varied as the amount of it sold, then, if instead of writing 2s. ∝ 2 bushels we wrote 2s. = 2 bushels, we could algebraically correctly arrive at the absurdity that 1s. = 1 bushel, &c.

Finally, in answer to the question, "Is steam a force?" I emphatically say, "No." We should speak of the expansive force, or the potential energy of steam, not of steam as a force. Steam is matter; force is not. When water is heated, a thermo-electric state is produced, and each molecule becomes charged with the same kind of electricity. Like electrics repel each other, and this repulsion it is which is the source of the expansive force of steam. It is not steam which *forces*, but the particles of steam which are *forced*. I really do not think I could possibly have found a better example with which to conclude. *Electricity* is the expansive *force* of steam—*i.e.*, steam is the result of intermolecular *potential energy*. This will, I believe, finally prove—firstly, that *force* and *energy* are one (dynamical force corresponding to potential energy, and statical force to latent energy); and, secondly, what I set out to prove from the beginning, namely, that *electricity is a form of energy*.

My time, being so fully occupied, will not allow me to enter in upon an endless controversy, so should be pleased if Mr. Fitzgerald would take the trouble to answer fully and comment on each point in my letter, and for the present I will try to rest contented with the results of such criticisms.

Leonard Joseph.

Telephones.

Your article of to-day should have good effect in deterring intending "Co-operative Telephonists" from dropping their money in an expensive and useless experiment. We wish to make some remarks on points upon which much turns.

Firstly, the expiry of the Bell patent in December, 1890, will only give to the public the Bell receiver pure and simple. It is true that the Bell telephone (including those forms subsequently disclaimed by Bell) transmits speech, under favourable circumstances, as clearly as a microphone, but that is not enough for public exchanges, where conditions are distinctly unfavourable. The telephone exchange at Boston, Mass., was started with Bell's instruments only, and was on the point of stopping when it was saved by the introduction of the Blake transmitter. The success of the Bell telephone on single lines was turned into failure when on multiple public lines, for which it was unsuited. The induction, leakage, cross-talk, &c., to which public lines are subject, overpower or destroy the currents produced by a magnetic transmitter, which on other lines is all that can be desired.

The co-operatives must therefore wait until a *workable* microphone patent expires; this will not necessarily be Edison's. We presume that if the co-operatives are to begin work at the earliest possible date, they will obtain their instruments from abroad, in which case they must take care that no unexpired patents are infringed, while if in their hurry they start with inferior instruments they will soon be very sorry that they parted from the National Telephone Company.

But even possessing the best of transmitters and receivers, they will do well to pause before trying to use them. The figures mentioned in their preliminary circular are ridiculous, both as regards establishment and maintenance. The word *co-operation* has no magical effect in lessening the expense of putting up and maintaining lines, instruments, and exchange rooms, and few firms conduct their business more economically than the National Telephone Company. Moreover, with two competing bodies, the price of wayleaves will run up considerably.

We have assumed that that the "co-operatives" want a service equal in value and extent to what they are now getting. An exchange covering only a small area is not worth having, and would, could in fact, have but little support. It is the long lines which are worth most, and they naturally cost most.

Whether the Post Office ultimately buys up the National Telephone Company, or whether it does not, intending exchange founders will do well to go slow.

It is, however, more than likely that the Post Office will decline to allow them a licence. Such things have happened.

The Stanhope Company, Limited,
J. S. Sawrey, *Director*.

November 30*th*, 1889.

Electric Light in Railway Trains.

I notice in your leading article on the above subject contained in this week's issue that the Great Northern Railway Company "are putting in hand several *bloc* trains," to be fitted with electric light, which is no doubt correct; but no mention is made of the fact that four trains have been running successfully for the last four years on that company's lines, which have been arranged and fitted entirely by the company's own staff. I mention this merely to show that the Great Northern Railway are not so far behind in the matter of train lighting as many would be led to suppose from a perusal of your article.

F. W. Cooke, *A.I.E.E.*

Great Northern Railway, Retford,
December 2*nd*, 1889.

Ozone.

In reference to your remarks *re* "ozone," and, of course, from a seaside place, "I beg to say that the seaside has nothing to do with the facts; that I accomplished the producing of ozone," or, as I would have called it, "electrical gas," on an unlimited commercial scale and for commercial purposes. This remarkable gas, now it can be had on so large a scale, will, I venture to think, open a new field, not only in the electrical and chemical, but in various other commercial industries; and I claim having first solved the problem of not only producing the gas, but applying the same to commercial industries. As you will know, Schönbein discovered ozone, 1845-46. Schröter, Bertholet, Fraüenhofer, Siemens and Babo, all experimented with the gas, but neither here in England nor in France, Germany or America, has anyone produced the gas on anything like a commercial scale. Some of these days I may be allowed to explain the serious difficulties I encountered during the many years I have had this problem in my mind. I am delighted to be able to report so splendid a result.

It will afford me great pleasure to let you view one of my ozone-plants. I only wished Prof. Bünsen, who used to say, "If ozone could be produced on anything like a commercial scale hundreds of uses could be found for it," could see my process at work.

Ernst Fahrig.

December 3*rd*, 1889.

Electropathic Quackery.

The first step has at length been taken in the direction of putting a stop to the system of foisting sham electrical appliances wholesale upon an ignorant public—a system which is a crying disgrace to the medical and electrical professions, as well as to our public Press. On Thursday last I had the pleasure of hearing the President of the General Council of Medical Education and Registration address Mr. Joseph F. Leeson, L.R.C.S., Edin., and L.R.C.P., Lond., as follows:—"I have to inform you publicly that the Council, after long deliberation, has come to the conclusion:—1. That you have committed the offence charged against you; 2. That the offence is, in the opinion of the Council, 'infamous conduct in a professional respect'; and 3. That the Registrar has been directed to erase your name from the Medical Register." Mr. Leeson had been summoned to appear before the Council: "For that he, being a registered medical practitioner, acts as cover of, or by his presence, advice and assistance, enables one Cornelius Bennett Harness, an unqualified person, to carry on the business or profession of a medical electrician, and to practice as if he were duly qualified, under the style of 'The Medical Battery Company, Limited,' and 'The Electropathic and Zander Institute,' at 52, Oxford Street, London; the said Cornelius Bennett Harness publicly advertising himself as 'The Medical Battery Company's Consulting Medical Electrician.'"

Sic semper similibus!

On the same day the Eminent one himself attended, and stated in cross-examination that "he certainly suggested to people who were suffering from various diseases that they should apply to him for advice and treatment on *electrical matters!*" He also stated that "he repudiated any degrees obtained in America or elsewhere, because it would interfere with his *reputation.*" (Save the mark!) He objected to state what his diploma was, "as it had nothing to do with the case." He could answer the question satisfactorily if he chose, but he was "not called upon to do so." Nor, probably, would he have felt called upon to answer a few questions on "electrical matters," which I should have much liked to put to him. Perhaps he might have referred me to "the highest living authority on Medical Electricity (one of the best-known physicians in the world)," or to "the late Editor of the *Electrical Engineer*." Let us hope that these gentlemen will make a noble endeavour to reverse the verdict of the "General Council" on the grounds that the Electropathic Belts are "constructed on sound scientific principles," and are most valuable aids to health."

Desmond G. FitzGerald, *M.I.E.E.*

Facts versus Fables.

An old version of "The Fox and the Goose," with a very little alteration, would apply equally well in the present day:—

A Fox there is who has such knowledge
That his dwelling house he calls a college,
And Geese flock to him from all quarters,
Bringing wives and sons and daughters;
He tells the Geese that their ills he's able
To cure with pills of vegetable;
And so Goose thinks he can, good lack!
For "Cackle" has great faith in Quack.
So he lives on Goose each day, I ween,
His house is built on Gander's Green,
His carriage wheels on Goose grease turn,
He fat of Goose for oil doth burn.

He plucks their feathers for his bed,
On down of Goose he lays his head.
He gets his Goose and eke his stuffing
By cramming Geese with pills and puffing.
He writes his puffs with gray goose quill,
Of Gooseberry-fool he has his fill.
He makes goose pay his college rent,
And calls himself the President!
And tho' 'tis strange, it's also true,
He is himself the "Members," too!.!

Foxhound.